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CAPTIVE BALLOONS OF THE FRENCH NAVY.

THE utility of captive balloons for the army is no longer disputed, and most of the European nations have followed the example given by our country. Why should not captive balloons render to the navy the same services as to the army? Is it not for the interest of the commander in chief of a squadron to follow at a distance the movements of the enemy's vessels, just as a general in chief should be informed as to the marching of the regiments with whom he is to fight? Is it not the business of the navy, too, to effect landings and to attack maritime strongholds? In this case, aerial observations may furnish it the most useful data.

These are the various questions that Lieut. Serpette, one of our most distinguished navy officers, has had under consideration for several years, and, owing to the perserverance of his studies, he has now succeeded in providing our Mediterranean squadron with a captive balloon outfit which can be carried to sea, be stowed away in an armorclad, from which ascensions can be made under the most favorable conditions. There has been much talk, in recent times, about these interesting experiments. We are now able to give the most exact data as to these new and remarkable tentatives in the use of balloons.

The captive balloon of the Mediterranean squadron was constructed at the military aeronautic works of Chalais-Meudon, under the direction of Commander Renard. It is of small dimensions (its capacity being but 320 cubic meters), and it is capable of lifting but one person to the extremity of its 400 meter cable. This little balloon is inflated with pure hydrogen, prepared beforehand and inclosed in compression tubes, whence it is forced at a pressure of 100 atmospheres. We have already spoken of these reservoirs of compressed hydrogen, which are now adopted for the inflation of our military balloons. The captive balloon is wholly inflated in a large arsenal building at the port of Toulon. When it is a question of operating it, a squad of marines guides it to its destination by means of equatorial ropes, as shown in Fig. 1.

After interesting experiments with captive balloons made on land at Lagoubran and Tamaris, in the latter part of the month of August, experiments of the same kind were entered upon at sea. The balloon was towed on the 21st and 23d of August by a ten foot cutter, a launch, or a torpedo boat. On the 29th the balloon was experimented with by Admiral Duperre, who remained for a long time at an elevation of 250 meters. During the first fortnight in September, the experiments on land being finished, a series was begun upon vessels either under way or at anchor. A large number of ascensions was made from the St. Louis, and more than thirty officers of all grades successively took their place in the car. Mr. Serpette, cutting loose from the St. Louis, made a free ascension. After reaching an altitude of 1,200 meters, he returned toward the surface of the sea and let his cone anchor drop thereon. This was picked up by the ship Audacieux, which carried it to the St. Louis.

Other experiments had previously been made, and with the greatest success, on board the guard ship Formidable. Lieutenant Serpette installed the post of ascensions at the extremity of the rear turret of the armorclad. The balloon being placed in the rear of the vessel, it was made to pass, through an ingenious system of cords and pulleys, to the upper part of the military mast (Fig. 2). There it was maneuvered by a cord, which, passing over a pulley at the extremity of the mast, was easily maneuvered from the ship's deck. Fig. 3 represents this experiment. All the officers who entered the car are unanimous in asserting that it is a convenient post of observation. In clear weather it was possible to distinguish, from Lagoubran, all the details of the coast from the entrance of Marseilles to the east extremity of the Hyeres Islands. No vessel could have escaped the investigations of the aeronaut within a radius of from 30 to 40 kilometers. With a silk cable, the balloon will be able to ascend in calm weather to an altitude of 400 meters. Lieutenant Serpette and the officers who, like him, have made ascensions in captive balloons have remarked a fact well known to aeronauts, and that is that the water, considered according to the vertical, is of a remarkable transparency. During these ascensions the details of the bottom were distinguished, even at great depths. This visibility naturally depends upon the nature of the bottom; but wherever the latter consists of rocks mingled with sand, it appears with such distinctness that it might be sketched, even at depths of 25 meters. This property has been utilized for following the evolutions of the Gymnotus, which was not lost sight of for a single instant, whatever was its depth of immersion. The small balloons constructed of Chinese silk at the Chalais-Meudon establishment are very strong, and are capable of resisting the action of an intense wind, or, what amounts to the same thing, they can be carried along with great speed by the vessels to which they are attached. We are told that on the 6th of September the torpedo boat Audacieux took no more than two hours to cover the twenty-one miles that separate the roadstead of Toulon from the anchorage place of the St. Louis in the roadstead of Hyeres. This is a mean speed, then, of 10·5 knots. The balloon was in ascension upon a 50 meter cable. With a vessel of large size, like an armorclad, it is better to do the carrying by lashing the balloon near the deck by its equatorial ropes. It will thus be firmly held and be capable of resisting much stronger breezes. A sort of shelter may even be made for it by means of properly arranged canvas. . . .

The experiments of which we have just spoken were begun in 1888 by Lieutenant Serpette. The best encomium that we can bestow upon their efficacy is to say that foreign nations have already seized upon processes that our navy has had the cleverness to be the first to experiment upon. At the end of September a captive balloon was operated at Wilhelmshaven, on board the German ship of war Mars. The ascensions were made directly from the after deck, and the balloon, in calm weather, ascended to 400 meters above the level of the sea.—*La Nature.*

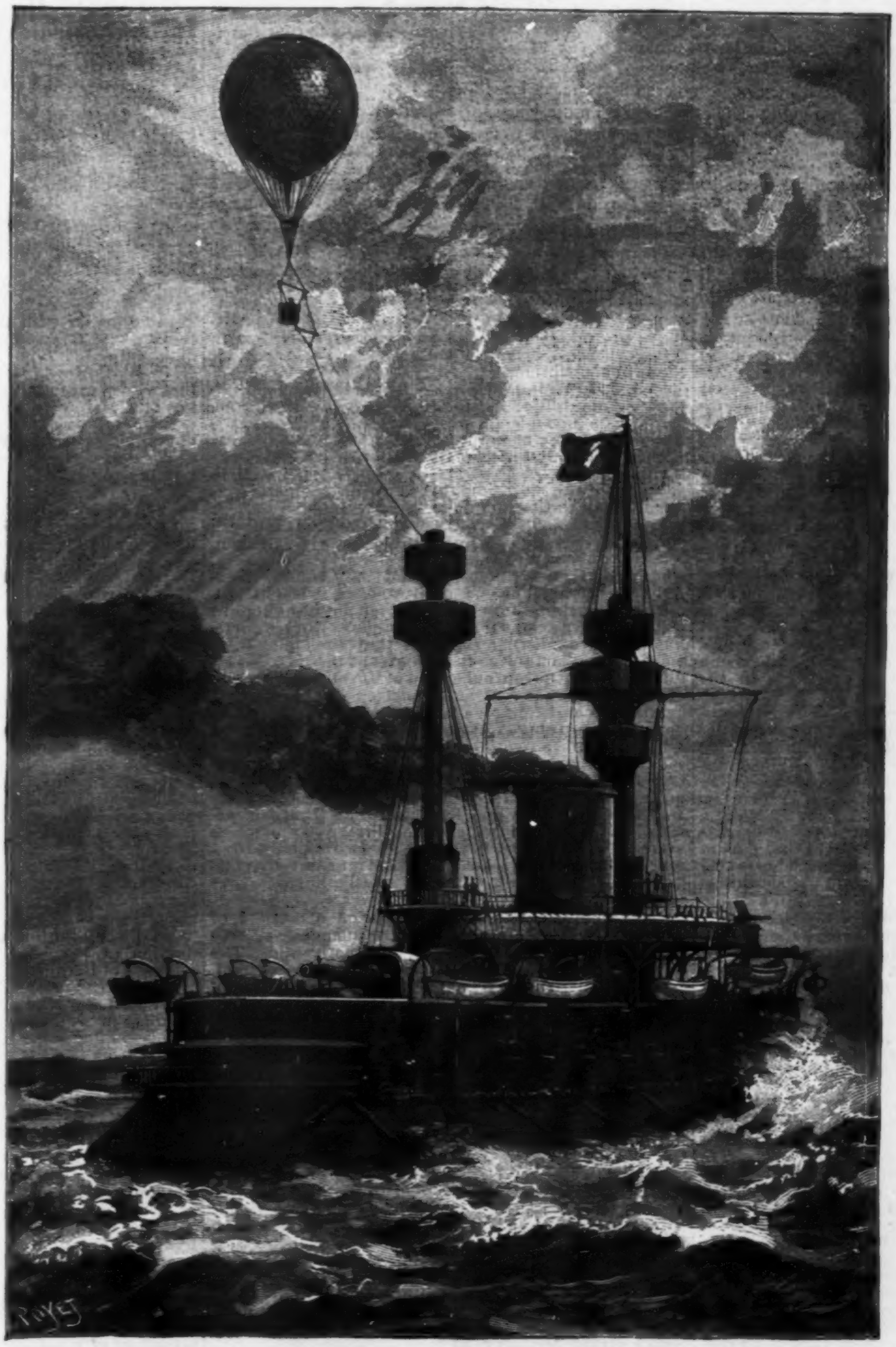


FIG. 3.—EXPERIMENTS WITH THE CAPTIVE BALLOON ON THE FORMIDABLE.

PHYSICS AT THE BRITISH ASSOCIATION.

IN section A, nine reports of committees and fifty-four papers were read. Perhaps the distinguishing characteristic of the section is its tendency to bifurcation on the slightest provocation. Several sections do not meet at all on the Saturday, and manage to get through their business comfortably by the Tuesday. Not so section A. On the Saturday, under the influence of electrolytical attractions and repulsions, there occurred a dissociation of the section into its constituent elements, accompanied by a migration of ions from places of high potential (in a Bramwellian sense) to places of low, or *vice versa*. In accordance with the law of ionic migration enunciated by Sir Frederick at the concluding meeting, the ions collected at the kathode were found to far exceed in number those collected at the anode.

To give even an outline of all the voluminous and multitudinous contributions to the section would occupy many pages, and would require that the writer should have received the training of a Succi or a Jacques before undertaking the task.

M. Du Bois read a paper on refraction and dispersion in certain metals. Kundt's method of observation with very thin electrolytic metal biprisms was used in this investigation. The dispersion was determined with all possible care, using four kinds of light defined by spectral lines. It was found that light, on passing from iron, cobalt, and nickel into air, begins by following Snell's law for small angles of emission, the refractive index being mathematically defined as the limit of the ratio of sines when the angle of incidence approaches the limit zero. The dispersion in the case of each of the three metals mentioned was found to be anomalous.

Sir William Thomson, F.R.S., in a paper on an illustration of contact electricity presented by the multicellular voltmeter, called attention to the modification of the force between the aluminum needles and the brass cells of the instrument arising from the "contact electricity" difference between polished brass and polished aluminum. In the instrument as at present made, the observed difference of potential on reversal amounts to as much as ½ volt. Thus the use of the multicellular electrometer gives a new

and very interesting direct proof of Volta's contact electricity.

Lord Rayleigh, Sec. R S., read a paper on defective color vision, in which he pointed out that the existence of a defect is probably most easily detected, in the first instance, by Holmgren's wool test; but this method does not decide whether the vision is truly dichromic. For this purpose Maxwell's color disks may be used. Lord Rayleigh found, in the case of some color blind persons he was examining, that it looked as though the third color sensation, presumably red, was defective, but not absolutely missing. When a large amount of white was present, matches could be made, in spite of considerable difference in the red component. But when red light was nearly isolated, its distinctive character became apparent. This view was confirmed by exeriments with the color box.

Mr. J. Swinburne, in a paper dealing with the question of the production of high vacua, called attention to the great superiority of the Geissler over the Sprengel form of mercury pump.

Profs. Barr and W. Stroud, in a paper on the use of the lantern in class room work, described a simple and convenient form of lantern for horizontal and vertical projection, and exhibited an apparatus for the preparation of lantern slides in large numbers from books, periodicals, etc.

Mr. W. N. Shaw read a paper on the general theory of ventilation, with some applications in which general laws of ventilation are estabished similar to Kirchhoff's laws relating to the distribution of currents in a network of conductors.

On Friday, September 5, there was a discussion on electrical units, opened by Mr. Glazebrook with a paper on recent determinations of the absolute resistance of mercury, in which he carefully compared and criticised the different methods employed by various observers. The best determinations of the ohm showed that it was very nearly, indeed, equal to the resistance of a column of mercury 106·3 cm. long and 1 square millimeter cross section at 0° C. Mr. Glazebrook strongly advocated the adoption of the number 106·3 instead of 106, and Sir William Thomson, Prof Rowland, Prof. Barker, and Mr. Preece expressed their concurrence in the desirability of the change.

Principal J. V. Jones followed with a paper entitled "Suggestions toward a Determination of the Ohm," in which he described the results of experiments undertaken at University College, Cardiff, in the spring of the present year. These experiments gave the ohm equal to the resistance of a column of mercury 106·307 cm. long and 1 sq. mm. sectional area. The method adopted was a modification of that due to Lorenz, in which a metallic disk is made to rotate in the mean plane of a coaxial standard coil. Wires touching the center and circumference of the disk are led to the ends of the resistance to be measured, and the same current is passed through this resistance and the standard coil.

The features of special interest in the method employed were: (α) The employment of a long trough for holding the mercury, and, instead of measuring the distance between the eletrodes, one electrode is kept fixed, while measurement is made of the distance moved through by the other between two positions of equilibrium of the galvanometer corresponding to two different rates of rotation of the disk. The latter measurement it is easy to make with accuracy, for the movable electrode may be rigidly attached to the movable headstock of a Whitworth measuring machine placed parallel to the length of the trough; and the two equilibrium positions may be taken near the middle of the trough, so as to avoid danger of curvature in the equipotential surfaces passing through the electrode in its two positions. A new difficulty is, however, now encountered, viz., the determination of the section of the mercury column. The capillary depression at the sides of the trough would make it a most serious task to determine the section by direct measurements to the required degree of accuracy. This difficulty is overcome by a further differential method, viz., by making observations with the mercury at two different heights in the trough. The sides of the trough in that part of it traversed by the movable electrode are assumed plane, parallel, and vertical. The trough used in the experiments was cut in paraffin wax contained in a strong casting of iron with its sides strengthened by outside ribs. The channel was 43·5 inches long, by 1·5 inches broad, by 3 inches deep. Paraffin was found, however, not to be perfectly satisfactory, and Prof. Jones expressed the opinion that a trough of worked glass or scraped marble would have been preferable. The position of the mercury surface in the trough was determined electrically by using a pointed steel spherometer screw. The screw may be moved downward until an electric circuit comprising the screw and the mercury is completed. (β) The employment of a brush of special form to secure good electrical contact at the periphery of the rotating disk. The brush consisted of a single wire perforated by a channel through which a constant flow of mercury might be maintained from a cistern of adjustable height. (γ) In connection with the measurements necessary to enable the calculation of the coefficient of mutual induction to be performed, Prof. Jones employs a coil consisting of only one layer of wire, the advantage of which is that every part is visible, and that nothing is done to alter the position of the wire after measurements have been made. If a coil consists of many layers, it is not quite easy to say where, after measurement, the lower layers go to under the pressure of the superincumbent ones.

In conclusion, the main suggestions offered for consideration were:

(1) That the time is ripe for a new determination of the ohm that shall be final for the practical purposes of the electrical engineer.

(2) That such a determination may be made by the method of Lorenz, the specific resistance of mercury being obtained directly in absolute measure by the differential method described.

(3) That the standard coil should consist of a single layer of wire, the coefficient of mutual induction being calculated by the formula given in the paper.

Sir William Thomson, in a paper on alternate currents in parallel conductors of homogeneous or heterogeneous substance, pointed out that when the period of alternation is large in comparison with 400 times the square of the greatest thickness or diameter of any of the conductors, multiplied by its magnetic permeability and divided by its electric resistivity, the current intensity is distributed through each conductor inversely as the electric resistivity; the phase of alternation of the current is the same as the phase of the electromotive force; and the current across every infinitesimal area of the cross section is calculated, according to the electromotive force at each instant, by simple application of Ohm's law. Further, that when the period is very small compared with 400 times the square of the smallest thickness or diameter of any of the conductors, multiplied by its magnetic permeability and divided by its electric resistivity, the current is confined to an exceedingly thin surface stratum of the conductors. The thickness of this stratum is directly as the square root of the quotient of resistivity, divided by magnetic permeability, of the substance in different parts of the surface. The dependence of the total quantity of electricity carried on extent of surface justifies Snow Harris, and proves that those who condemned him out of Ohm's law were wrong, in respect to his advising tubes or broad plates for lightning conductors, but does not justify him in bringing them down in the interior of a ship (even through the powder magazine) instead of across the deck and down its sides, or from the masts along the rigging and down the sides into the water.

Sir William Thomson read a paper on anti-effective copper in parallel conductors, or in coiled conductors for alternate currents. It is known that by making the conductors of a circuit too thick we do not get the advantage of the whole conductivity of the metal for alternate currents. When the conductor is too thick, we have in part of it comparatively ineffective copper present; but, so far as is known, it has generally been supposed that the thicker the conductor the greater will be its whole effective conductance, and that thickening it too much can never do worse than add comparatively ineffective copper to that which is most effective in conveying the current. It might, however, be expected that we could get a positive augmentation of the effective ohmic resistance, because we know that the presence of copper in the neighborhood of a circuit carrying alternating currents causes a virtual increase of the apparent ohmic resistance of the circuit in virtue of the heat generated by the currents induced in it. May it not be that anti-effective influence such as is thus produced by copper not forming part of the circuit can be produced by copper actually in the circuit, if too thick? Examining the question mathematically, Sir William finds that it must be answered in the affirmative, and that great augmentation of the effective ohmic resistance is actually produced if the conductor is too thick, especially in coils consisting of several layers of wire laid one over another in series around a cylindric or flat core, as in various forms of transformer.

Prof. J. A. Ewing, in a most interesting and important communication (*vide Phil. Mag.*, September, 1890), exhibited a model to illustrate some novel ideas on the molecular theory of induced magnetism. The present notion of a quasi-frictional resistance opposing the turning of the molecular magnets lends itself well to account for the most obvious effects of magnetic hysteresis and the reduction of hysteresis by vibration. On the other hand, it conflicts with the fact that even the feeblest magnetic force induces some magnetism. Reference was made to another (and not at all arbitrary) condition of constraint, which not only suffices to explain all the phenomena of hysteresis, without any notion of friction, but seems to have in it abundant capability to account for every complexity of magnetic quality. Prof. Ewing supposes that each molecular magnet is perfectly free to turn except in so far as it is influenced by the mutual action of the entire system of molecular magnets. A model molecular structure was exhibited, consisting of a large number of short steel bar magnets strongly magnetized, each pivoted upon a sharp vertical center, and balanced to swing horizontally. The bars swing with but little friction, and their pole strengths are sufficient to make the mutual forces quite mask the earth's directive force when they are set moderately near one another. The group is arranged on a board which slips into a large frame wound round the top, bottom, and two sides, with a coil, through which an adjustable current may be passed to expose the group to a nearly homogeneous external magnetic force.

Sir William Thomson read a paper on a method of determining in absolute measure the magnetic susceptibility of diamagnetic and feebly magnetic solids. The method proposed consisted in measuring the mechanical force experienced by a properly shaped portion of the substance investigated, placed with different parts of it in portions of magnetic field between which there was a large difference of the magnetic force. A cylindrical or rectangular or prismatic shape terminated by planes perpendicular to its length was the form chosen; the component magnetic force in the direction of its length was equal to $\frac{1}{2}\mu(R^2-R'^2)A$; where μ denotes the magnetic susceptibility, RR' the magnetic force in the portions of the field occupied by its two ends, and A the area of its cross section.

Lord Rayleigh read a paper on the tension of water surfaces, clear and contaminated, investigated by the method of ripples. The ripples were rendered visible by a combination of Foucault's optical arrangement with intermittent illumination. Two frequencies were used, about 43 and 128 per second. The surface tension of a clean water surface, in c. g. s. measure, was found to be 74·0, thus confirming observations made with capillary tubes. Water saturated with olive oil had a surface tension of 41·0, and saturated with oleate of soda a surface tension of 25·0.

Mr. W. N. Shaw reported on the state of our knowledge of electrolysis and electro-chemistry.

Mr. J. Hopkinson read a paper on the inland compared with the maritime climate of England and Wales. For special reasons Buxton, Woburn (Apsley Guise), Croydon, Cheltenham, and Churchstoke were chosen to represent the interior of the country, while Scarborough, Lowestoft, Babbacombe, Worthing, and Llandudno were chosen to represent the sea coast. The places were so chosen that the mean position, latitude, and longitude of the five inland places should closely approximate to those of the maritime. As the result of observations extending over the decade from 1880–89, he concluded that, so far as regards our comfort and most probably also our health, our maritime climate is on the whole superior to our inland climate, being warmer, owing (it is most important to observe) to the nights not being so cold, while the days are no hotter, the extremes of temperature being much less, the air rather less humid, the sky less cloudy, and the rainfall less.

Prof. Ramsay read a paper on the adiabatic curves for ether, gas and liquid, at high temperatures. The method adopted in the experiments was an ingenious one, and consisted in determining the velocity of sound in the vapor by Kundt's dust figures, from observation of the wave length and the pitch of the note emitted by the stroked tube containing the vapor. This process gives the ratio of adiabatic and isothermal elasticity from which the former elasticity can be calculated as the latter is known.

Prof. Ostwald read an interesting paper on the action of semi-permeable membranes in electrolysis, in which he gave an account of experiments upon the passage of an electric current through solutions in series separated by semi-permeable membranes, and pointed out the importance of such phenomena to physiology. He explained that a semi-permeable membrane would allow ions of one kind to pass through, but arrest ions of anther kind, and thus act as though it were a metallic electrode.

Prof. C. Piazzi Smyth sent a paper on photographs of the invisible in solar spectroscopy. Two photographs were shown, each measuring 40 inches long by 20 inches high. They represent in reality only very small portions of the faint ultra-violet of the solar spectrum, but on a whole scale of 57 feet long from red to violet, and are located quite outside the spectral limit of variability to the human eye, with the grating spectroscope concerned, whether under summer or winter sun.

Profs. Rucker and Thorpe contributed a paper on regional magnetic disturbances in the United Kingdom, and this was followed by a paper upon similar disturbances in France, by Prof. Mascart. A point of great interest in connection with these papers was the continuous nature of the disturbances extending from the one country across the channel to the other.

Prof. Lodge, in a paper on electrostatic forces between conductors, gave an account of an investigation into the forces between electric resonators as examined experimentally by Boys, and therefrom branched out into several allied subjects connected with the mechanical forces of electric pulses and waves.

Prof. Fitzgerald communicated several papers on mathematical physics to the section. One of these bore what would have been an attractive title, "An Episode in the Life of J," had it not been for a parenthetical addition, viz., "(Hertz's Solution of Maxwell's Equations)." It may be remarked that J has nothing to do with Joule or his equivalent, and that the episode referred to was not of the popular anecdotal type.

Mr. W. Barlow, in a paper on atom grouping in crystals, called attention to some very interesting properties of the simpler kind of symmetrical grouping of points, and pointed out an easy and effectual method of studying them by using a model consisting of equidistant parallel planes of homogeneously distributed points represented by beads.

Mr. W. H. Preece read a paper on the character of steel used for permanent magnets. Samples of steel for the experiments were obtained from all the leading firms, and after magnetization were tested by a magnetometric method. The marked superiority of the Marchal magnets over those made of English steel is due either to the quality of the steel or to the mode of tempering—most probably the latter.

Prof S. P. Thompson read a paper on the use of fluorspar in optical instruments, in which he referred to the existing uses of fluorspar for experiments on radiant heat, and in the "apo-chromatic" microscope lenses of Zeiss. The latter application derives its importance from the extremely low disperson relatively to the mean refractive power of the material. To these applications the author now added that of the construction of spectroscopic direct vision prisms, and he described two prisms, both constructed for him by Mr. C. D. Ahrens—one consisting of a fluor prism cemented between two flint glass prisms and the second consisting of one Iceland spar prism cemented between two fluor prisms. The former was considerably shorter than the ordinary direct vision prism of equal power, the latter had the property of polarizing the light as well as dispersing it, and presented the novel feature of a true polarispectroscope.

Mr. F. T. Trouton read a paper advocating the introduction of a coefficient of abrasion as an absolute measure of hardness.

Mr. F. H. Varley exhibited and explained the action of a new direct reading photometer—an ingenious and compact instrument, in which intermittent illumination is employed for equalizing the intensity of illumination from two sources of light.—*Nature.*

[ENGINEERING AND MINING JOURNAL.]

WILLIAM H. CILLEY.

WILLIAM H. CILLEY was the ablest man I ever knew, and his career was very remarkable. He could run and repair, perhaps build, a locomotive at the age of seventeen. He could construct and manage gas works at twenty. He had served an apprenticeship in hydraulic and quartz mining, and was a mine owner at twenty-two. Having lost his money, through others, and being left almost penniless in Chili when twenty-three years of age, he took a position as section hand on a railroad, and within a couple of years had risen through intermediate grades to the position of superintendent of construction, and then of contractor for building Andean railroads, had achieved a brilliant reputation for managing men and conducting difficult engineering operations, and had made a fortune.

When he was twenty-six the Chilian government, then at war with Spain, intrusted him with the mission of buying in the United States ammunition and heavy guns for the forts at Valparaiso. The arms were to be paid for only on delivery in South America, and the risk was great. The United States government was faithful to the obligations of a neutral power, and the Spanish agents were forewarned and vigilant. The remarkable financial and diplomatic abilities of the young man enabled him to perform this difficult and delicate mission with success.

Limitations of space forbid giving an account of many noteworthy achievements of Mr. Cilley; but his building of the Oroya Railroad and his management of it for years amid all the dark times of Peru, and his

preservation of the greatest plans of Meiggs from total annihilation, certainly merit mention.

When the obstacles encountered in the construction of the Oroya Railroad above San Bartolome became so great that the ablest engineers pronounced further construction impossible, Mr. Meiggs, who had staked his reputation on the building of this road, called Mr. Cilley to his assistance and gave him full control. The position was one requiring the very highest order of talent.

The road follows the cañon of the Rimac River, a narrow tortuous defile hemmed in by mountains whose summits tower thousands of feet above the stream. The precipitous cliffs occasionally rise vertically from the water's edge to dizzy heights, making it impossible to trace out the line on the surface. Everywhere the laying out of the line was extremely difficult, often necessitating the construction of a trail before any work could be commenced or even a point given for commencing work. At places the ground was unstable, liable in the wet season to slide in huge avalanches, as at Matucana, where once the mountain side slipped into the gorge, damming the river in such a way as to threaten the existence of Lima. It was necessary always to locate fifteen or twenty miles ahead of construction lest some new obstacle should be encountered which would compel a new location commencing many miles back. Frequently, either to gain greater length (in order not to exceed the maximum grade allowed) or to avoid treacherous ground, the line was run up lateral ravines or zizzaged up the sides of the cañon. Just above Chicla there is a spot where a line drawn across the narrow cañon would cut the roadbed five times. Not far below this spot the expedient of tunneling into the solid mountain merely to gain grade was resorted to—an expedient afterward more fully developed in the "spiral" tunnels of the Swiss St. Gothard Railroad.

The region through which the road runs is barren, treeless, and destitute of all supplies. Every stick of timber, every pound of iron, powder, coal, tools, provisions, and grain had to be brought from foreign countries and then transported on the backs of imported animals over miles of dizzy trails built for the purpose. Even the labor had to be brought from abroad, principally from Chili, Bolivia, and China. Many of the workmen were of the roughest class, addicted to liquor and gambling, armed with knife or revolver, and ever ready to fight. It took a strong and fearless man to control these when excited. But Mr. Cilley was a natural leader of men, and the laborers soon learned to respect, love, and fear him. Among Chilian roughs he was known as "*el diablo flacco*"—the thin devil.

An additional obstacle was the terrible Verrugas-fever, which made dire inroads into the ranks of the laborers, and was so dreaded that at times it was difficult to get the engineers and men to continue on the work.

All these things rendered the building of this road a feat unequaled in the whole history of railroad construction. In comparison with it the great engineering achievements in Europe or the United States seem only light tasks, since in these more fortunate countries adequate supplies of material and ample machine shops are close at hand, and a mistake which on the Oroya would involve months of delay and huge costs can be easily remedied. An adequate description of this work is yet to be published. Some years ago I began to collect the material for such a work, but abandoned the idea on learning that Mr. M. Van Brocklin proposed to write a memoir on the subject. I hope that this eminent engineer, who rendered such valuable services on the road, will soon make public the full details of this grand undertaking.

The genius of Mr. Cilley was fully equal to the task imposed on him by Mr. Meiggs, and before long the "impossible" was an accomplished fact. The road was graded and the tunnels were all pierced as far as the terminus (Oroya) when the Peruvian government declared itself unable to pay for what had already been finished, and went into bankruptcy, suspending further operations. The rails had been laid only about eighty miles, but all the great engineering problems had been successfully solved. So excellent was the work on the completed sections that, although the line for fifty miles is a constant succession of curves, switchbacks, tunnels, and bridges, has an average grade of 3½ per cent. and passes over very dangerous ground, no serious accident occurred during eighteen years of operation under Mr. Cilley's management.

Henry Meiggs, on his deathbed, called for Mr. Cilley and charged him with the completion of his greatest work, the fulfillment of his dearest ambition. This was the finishing of the Oroya Railroad and its main branch, and the development of the Cerro de Pasco mines. Mr. Cilley at once began operations. He devised an excellent plan for working the mines, formed a company, raised a large working capital, and built and brought to Peru a complete 80-stamp mill, which has been described in the *Engineering and Mining Journal*. So perfect was the scheme, so well worked out in all its details, that it is my sincere belief that it would have been a brilliant success had it been carried out under the management of Mr. Cilley, who possessed the respect and confidence of the Peruvians to a wonderful degree.

Certain powerful and unscrupulous men in Lima were so well convinced of the value of this project that they undertook to "freeze out" the mass of stockholders and get the whole affair in their own hands. Taking advantage of Mr. Cilley's absence in the United States, they robbed the company of $300,000, under pretense of a loan to the bankrupt government. Then came the war with Chili and the civil war, and until 1866 all peaceful enterprises were of necessity abandoned. That the Oroya road was not destroyed during these troublous times, when the breaking of the line often would have been of immense advantage to one side or the other, and was repeatedly threatened, is proof of the great diplomatic ability of Mr. Cilley, who, by his firmness and tact, saved the road and preserved other important interests intrusted to his care. He commanded the admiration and respect both of the Chilians, who had not forgotten the important services previously rendered to their country, and of each faction of the Peruvians, to whose aid he had often come when they were in distress. For when all others shrank from the perilous and perhaps thankless job, he had accepted the call of the government to hold the position of general superintendent of all the Peruvian railroads during the war, and had performed many a daring and useful exploit, repeatedly risking his life for others, and never asking any reward. Surely no man of late years has done more for Peru than this foreigner, to whom came all sorts of men for aid, comfort, and advice, and never in vain.

As soon as peace was established Mr. Cilley formed new plans for developing the country. A new mining scheme was devised adapted to the changed conditions as well as a most extensive plan for completing the railroads, opening new districts, and re-establishing the financial credit of Peru. His aid was most important in forming and carrying through the "Grace contract," so called from the principal negotiator, Mr. M. P. Grace, and his advice was sought by both parties. The Peruvian executive recognized the value to Peru of this proposition, and favored it; but Chili also saw its importance and opposed it, and for two years the Peruvian congress put off its legal ratification. Before the final agreement was reached Mr. Cilley had died. His

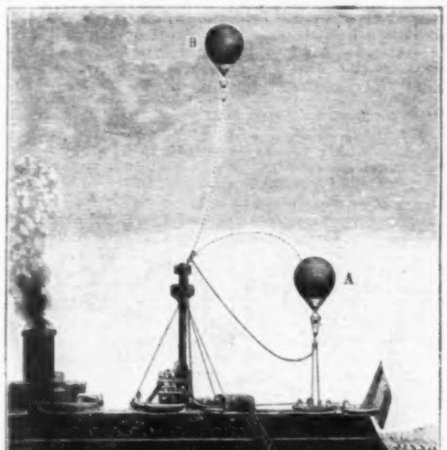


FIG. 2.—MANEUVERS OF THE CAPTIVE BALLOON ABOARD AN ARMORCLAD.

A. First position. B. Position during ascension.

tremendous exertions during so many years and amid so many difficulties had been too great, and on September 10, 1889, he passed away.

His courageous devotion to duty, his intense loyalty, his generosity and complete effacement of self for the sake of others, his keen sense of justice and chivalrous integrity merited and received the reverential love of his many friends. The proofs of his genius in railroad building, to quote one who closely watched his career, are hewn in letters of granite in the rugged defiles and on the lofty slopes of the Cordillera, where, at a height of 15,600 feet, the highest tunnel in the world, nearly 4,000 feet in length, pierces the summit. Although his remarkable ability is known and appreciated in Chili and Peru, and in the highest engineering circles of England and the United States, yet, owing to his invincible repugnance to mere newspaper notoriety, his invariable custom of giving to those associated with him even more than their due share of credit, and more especially on account of the darkness in the land where he last worked, his countrymen have generally had opportunity to learn but little of his heroic character and deeds.

At his death Lima draped herself in mourning, flags drooped at halfmast, and private and public offices were closed. The president of the republic, represented by his aide-de-camp, the president of the senate, and the secretary of the treasury were among the pall bearers. Thousands of mourners followed the coffin, which was guarded by a troop of cavalry in representation of the army, and at the tomb Peru expressed her grief and gratitude through the lips of her most eloquent statesmen. A. D. HODGES, JR.

October, 1890.

ECONOMY OF STEAM HEATING OF PASSENGER CARS.

WHAT follows is an abstract of a paper lately read at Horton, Kan., before a meeting of trainmen of the Rock Island and connecting lines, by Mr. J. H. Sewall, General Manager of the Consolidated Car Heating Company:

The subject of steam heating for passenger cars was entertained at an earlier date than is generally supposed, as patents were granted more than twenty years ago to different parties for this purpose. Their devices were tried with more or less success, but the perfection of them had not been enough to elicit favorable approval by the railroad companies until the winter of 1882-83. The benefits of steam heating as compared with fire heating are: Safety in case of wreck, economy of fuel, and comfort.

Regarding safety in case of wreck, I need not call your attention to the cases where the car stove has not only destroyed valuable property, but has also burned people alive with as relentless a spirit as did our misguided forefathers burn the so-called witches at Salem. . . . I think you will agree with me that the most striking example of the benefits of steam heat in this respect was on this very railroad, or rather that portion of the Denver & Rio Grande over which this road runs its trains between Colorado Springs and Denver, early in November, 1888, when one of the first steam-heated trains the Rock Island ever ran went into collision with a Denver & Rio Grande train heated by fire. The result, you will remember, was the burning of more or less of the D. & R. G. train, while the Rock Island train was in no way injured by fire.

The economy of fuel is governed by the cost of coal, which differs greatly in different localities. On this division of your road the cost of hard coal, as burned in the stoves and heaters in cars, is about 200 per cent. more than the cost of soft coal that is consumed on the locomotive. The amount of condensation indicates the amount of fuel used. It has been demonstrated by test that a steam-heated car will condense about 65 lb. of water per hour. And if 1 lb. of soft coal will evaporate 5 lb. of water, it is evident that 13 lb. of soft coal have been expended per car per hour. Assuming that soft coal costs you here, on the tender, $2 per ton, then the 13 lb. would cost 1·3 cents for one car for one hour, and for 24 hours 31·2 cents. And as cars equipped with any hot water device, in which the water is heated by fire, require that fire should be kept in the cars for a day of 24 hours, if cars are in service, in order to prevent freezing, it is no more than fair to make a comparison between fire and steam for a day of 24 hours. We have assumed that the coal burned on the locomotive costs $2 per ton.

The hard coal burned in the stoves and heaters costs the Chicago, Rock Island & Pacific, at Colorado Springs, 104 per cent. more, and at Kansas City 211 per cent. more than soft coal; and as difference in price is all we want to make the comparison, we will, in this ratio, assume that the coal burned in the cars costs, at Colorado Springs, $4.08, and at Kansas City $6.22 per ton. In order to make a correct estimate of saving at these two points we will take the result of the tests made by the C., B. & Q. as to the amount of hard coal required to heat a car for a day of 24 hours with stoves. This was found to be 200 lb. of anthracite. At Colorado Springs hard coal costs, we assume, $4.08 per ton, or 40·8 cents for 200 lb. for one car one day, as against 31·2 cents per car per day when heated by steam. This small saving is attributable to the fact that your hard coal is mined in the vicinity of Colorado Springs, and is remarkably cheap, while the soft coal being mined in the East is much higher relatively in price. But at Kansas City there is a saving of 31 cents per car per day, as hard coal at that point costs, we assume, $6.22 per ton, or 62·2 cents for 200 lb., as against 31·2 cents for soft coal burned on the locomotive at $2 per ton.

In this relation it may be well to refer to a paper read before the Western Railway Club during the month of March, 1887, by William Forsyth, of the Cincinnati, Burlington & Quincy, an extract from which was published in the *Railroad Gazette* of March 18, 1887:

"The expense which some of the recent accidents

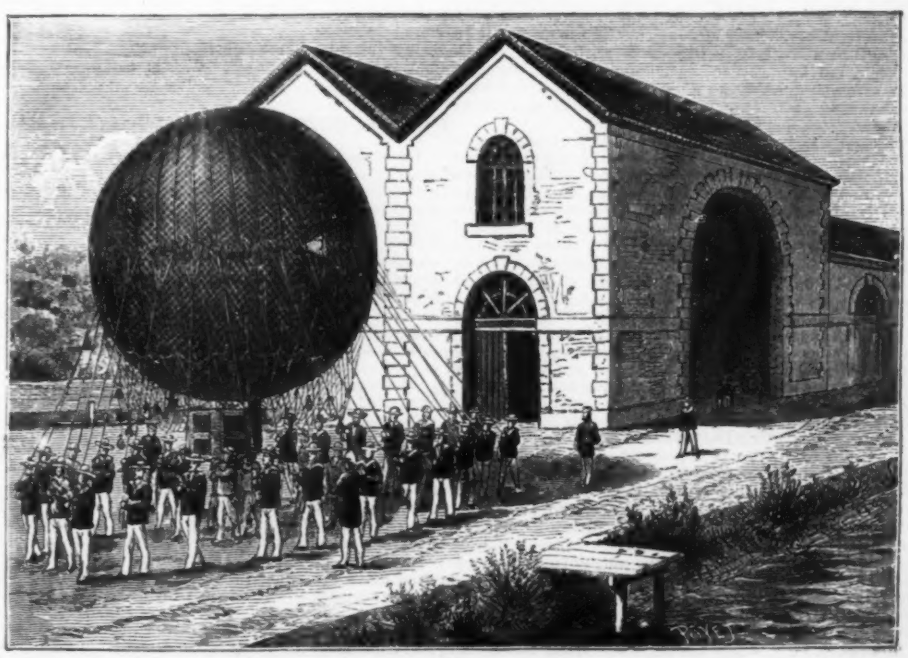


FIG. 1.—CARRIAGE OF THE NAVY CAPTIVE BALLOON.

have caused the companies in loss of property alone has amounted to $20,000 or $30,000, without paying the damage for loss of life, and the whole sum lost in any one of these accidents would no doubt be sufficient to equip almost any road with a complete system of steam heating by the continuous method, even at the high prices now charged for it. Continuous heating is really an economical system as a matter of economy of fuel. . . . There are very little data to show how much the stoves or heaters require. I have endeavored to get a figure for the continuous system, and I have some figures obtained by our own experiments last year with the different forms of hot water and steam heaters from tests we made on our own road. . . . I found as the result of extended tests that the Searle, Baker and Westinghouse heaters use on an average about 200 lb. of anthracite coal per car per day; some of them use even more than that. . . . On our Chicago division we have about five trains a day which average 10 cars each, and a number of other trains, which make the equivalent of 15 10-car trains per day. I found the entire amount of anthracite coal used during a winter of 150 days would be 2,250 tons, at $6 a ton would cost $13,500. That is an item, then, for the stoves.

"To get the amount of fuel required by the continuous heating method, I take as an average condensation for cold weather 50 lb. of water per car per hour."

There is no doubt that Mr. Forsyth's estimate was low, by tests that have been made by the company which I represent. We find that an average of 65 lb. per car per hour is right. This average is based on an average temperature and an average pressure with one square foot of heating surface to 25 cubic feet space in the car to be heated. Mr. Forsyth further says:

"On a basis of 50 lb. per car per hour, with our poor Iowa and Illinois coal it will require 10 lb. of coal burned in the locomotive to heat each car; for a train of 10 cars it would require 100 lb. of coal. For the 15 10-car trains per day of 150 days, as before, it would give 1,125 tons each at say $2 a ton, which would amount to $2,250. Deduct this from the expense of $13,500 arrived at in the cost of the stoves, and we have a saving of $11,250 in fuel in one winter on one division.

"To burn this additional amount of coal, 100 pounds per hour, how much additional heating surface do we require? With our ordinary 18 sq. ft. grate engines we can easily burn 100 lb. of coal per square foot of grate per hour, and I have known this figure on one road to be as high as 165 lb., but calculating 100 lb. per hour per square foot for grate, our additional 100 lb. of coal would simply require one additional square foot of grate surface, and if we take 50 sq. ft. of heating surface to one square foot of grate, and take a 2-in. tube 11 ft. long as having 6 sq. ft. of heating surface, we would require about 8 additional tubes; so that for heating a 10-car train we would require on a locomotive one additional square foot of grate surface and 50 sq. ft. of heating surface, which latter is represented by eight 2-in. tubes of the ordinary length."

Everything that was ever made does its work better if the proper care is bestowed upon it, and steam heating devices are no exception to the general rule. The points necessary to be observed in order to keep out of trouble are simple, but to obtain the very best results, the more brains put into the work the better. Frost must be prevented, and to this end all trainmen must work in harmony. The engineer should carry a uniform pressure in the train pipe, and should not shut off steam without giving the trainman an opportunity to drain the portion of the device under his charge. And to insure the greatest economy in fuel, as well as to reduce the danger of frost, all pipes should be properly insulated that are exposed beneath or between the cars.

This should be carefully looked after by the car inspector as well as by those who equip the car, as many dollars may be wasted and much trouble caused by what may seem a small neglect. The trainmen should see that the drip and couplings are warm and working right when stopping at stations, and never allow the temperature in the cars to be above 70°.

A PROPOSED RAILROAD APPROACH TO NEW YORK CITY.

In 1876, while looking over a map of New York City and its vicinity, it occurred to the writer of this article that Long Island and Staten Island were favorably situated to afford a very superior route for railroads to approach New York from the south and west. A further study of the subject satisfied him that it might at the same time be made a connecting link between railroads coming in from the former points and those coming in from the east and north.

The plan was to cross the Arthur Kill at some convenient point, by a bridge from New Jersey to Staten Island, thence on Staten Island to the Narrows, thence by a tunnel under the Narrows and Bay Ridge to Long Island, thence through or around Brooklyn to the vicinity of Lawrence's Point, and thence by a tunnel under the East River to Westchester, where it could form a junction with the various railroads coming in from the east and north. The full line on the sketch map shows such a route.

From all that the writer could learn of the character of the bottom of the Narrows, it did not appear to be such as to present very serious obstacles to driving a tunnel through it, and he believed that a tunnel might be so constructed as to be permanent. He gave this part of the problem considerable study.

A glance at the accompanying map will be an assistance in understanding the advantages of such a route, of which the following is a general description. It is not at all intended for an exact location.

1. The great facility it would afford in reaching New York. The city of Brooklyn is now well supplied with a system of elevated railroads, terminating at various important points on the East River. Two or three substantial bridges could be built across this river for what one would cost across the North River from Jersey City or Hoboken, and these bridges would have the decided advantage of distributing the traffic over a proportionately greater number of convenient points in New York City, while the railroads from the north and east would continue to enter the city by their present routes. By these means a very material assistance would be given to the solution of the rapid transit problem in New York.

2. It would place Long Island and Staten Island on a through line of railroad, a very important consideration, when it is remembered that the large and rapidly growing city of Brooklyn is completely isolated from the mainland. These islands would also have their value as suburbs greatly enhanced.

Branch tracks extending along the shores of the Bay and the Brooklyn shore of the East River would be of decided benefit as terminal facilities.

3. The advantages that such a railroad would afford in receiving and shipping goods might soon cause the erection of large storage warehouses around the outskirts of Brooklyn, where heavy goods could be received and repacked for shipment directly by rail instead of bringing them to New York and carting them about the streets by horse power, thus saving a large percentage in the cost of handling and preventing the present crowded condition of the streets from becoming much worse.

Finally. No more direct route connecting New England with the South, West, and the coal regions can be found than by the line above described.

A bridge has already been built across the Arthur Kill and a railroad on Staten Island. These are not shown on the map. A movement is now on foot to tunnel the Narrows and extend the railroad on to Long Island. That the improvement will end there is not at all probable.—*L. L. Buck, in Railroad Gazette.*

PROPOSED ALL-RAIL CONNECTION FROM NEW JERSEY TO NEW ENGLAND.

(The heavy line shows the proposed route across Staten Island and Long Island.)

ELECTRO-WELDED PROJECTILES.

In a paper read before the Society of Arts, Boston, Mass., Lieut. W. M. Wood described a new method of constructing wrought-steel projectiles, and exhibited samples of the new constructions.

The new shell is formed of three mating portions, which, after preparation, are welded together to form the whole. The head or point and the base piece are forged in dies to proper shape and finished, the fuse hole being cut and threaded in the base piece. The central portion is formed of solid-drawn steel piping, cut and turned to exact size and length. The three portions are then welded together by the electro-welding process. At each of the welding lines a bur is left projecting outward and inward. The outside bur near the point is either ground off or turned to form a collar enlargement of neat diameter with the bore of the gun, for the support of the forward portion of shell in an exact central position. The bur at the rear end is ground off and the dovetail groove for the soft metal rotating band is cut, leaving the projectile ready for the hardening process and use.

In the construction of shrapnel a longer and more detailed process is necessary. The point and base are of compressed cast steel, and the central body is of solid-drawn steel tubing. The point is first welded to the tubing, next the flame tube from the fuse to the powder chamber in the base is crimped in at the forward end, and the surrounding space within the main tubing filled with bullets or musket balls. Next, the front diaphragm of the powder chamber is crimped to the flame tube and the shell subjected to the second or final welding process. The dovetail groove for the soft metal rotating band is then cut and the welding burs ground off, leaving the shrapnel ready for use.

This process reduces the cost of the shells to an extreme minimum in comparison to that of the moulded steel or armor-piercing shells, and the process having now been successfully applied to the larger makes, can easily be adapted to those of the smaller shells and cartridges.

ELECTROLYTIC PRODUCTION OF PURE IRON.

A process for the direct conversion of pig iron into wrought or ductile iron, without decarbonization by heat, has been invented and worked out into practical shape by Dr. Stephen H. Emmens, of Emmens, Pa., the inventor of the powerful explosive which bears his name and is now most successfully going through the ordeal of government tests. Wrought iron, so called, is to-day most universally produced by the process of puddling cast or pig iron, the higher and costlier grades of pig being used, especially in the production of the finer brands, known as "Norway" and "Swedish" iron. The puddling process may be said to be simply the burning out of the contained carbon by the agency of heat and oxygen, and successful puddling requires great skill and extremely hard labor, which must be paid for accordingly. The Emmens process, as to the actual conversion, requires no heat and no skilled labor, but for merchantable bar or sheet iron the product is simply heated and rolled or hammered. The process is hardly to be described as a decarbonization of pig iron. To coin a word for the purpose, "defecation" of pig metal would more accurately describe what takes place. The process is electrical, and the pure iron is extracted from the crudest and most impure pig iron or pot metal with as much facility as from the best charcoal pig.

Many attempts have been made to force iron into the list of electrolyzable metals, but failure has marked all efforts except in the electroplating of engravings or copper electrotypes with a coating of hard iron. The difficulty has been completely overcome by Dr. Emmens, whose electrolyte and current treatment are such as to form a perfectly reguline and closely adherent cathode of iron of almost chemical purity, which then only needs washing, heating and rolling to produce an article equal to the finest Swedish iron, being very soft and easily worked. The inventor claims to be able to make the iron from pig, and put it into merchantable shape at a less cost than the ordinary puddling process, and at the same time to further cheapen the cost by using the very lowest priced grades of pig iron. If this be true, and there seems to be no reason why it is not, the effect can hardly be safely predicted. Electricity as a commodity is now a very cheap article, and its production is as certain and uniform as the laws of science can make it. It is said that the residue of the anode, composed of graphite, silicon, sulphur, phosphorus, etc., from which the iron is, of course, absolutely freed, makes a valuable basis for mineral paint, and probably this is the case.

The metallurgist will at once realize the value of this process, if for no other reason than that it at once

makes available for the production of iron immense deposits of iron ore in various parts of the country which are now useless owing to the prohibitive quantities of phosphorus and sulphur they contain. Such ores are not available even for the Bessemer or open hearth process, which produces low steels containing a very small proportion of carbon. But for the Emmens process these ores are practically as good as any. They can be smelted, run into slabs of proper size and shape, and the only effect of the impurities is upon the character of the anode residue. The cathode will in all cases be practically and almost chemically pure iron. Not only that, but when heated and rolled or hammered, its quality is of the very highest grade. If, as seems to be fairly within the truth, such iron can be produced from such pig at a cost below or even the same cost as an equal quality by the puddling and refining furnaces, the result must be necessarily important in the future development of the iron industry.

The process is of interest also to the electrical fraternity in point of utility. The forged product is said to be surpassing in its fitness for magnet cores for all purposes, on account of its great purity and the low resistance of a magnetic circuit composed of it. This would seem to be true by comparison. The most impure cast iron has the least magnetic permeability, and the coefficient of the latter rises as the cast iron approaches the character of wrought iron. Swedish iron is the purest commercial iron we are acquainted with, and we all know its splendid magnet-making properties when energized. The Emmens iron, being still purer, ought to make a proportionately better electro-magnet. If it does, the electrical industries alone will create a heavy demand for the new product. — *Electrical Review.*

[Continued from SUPPLEMENT, No. 777, page 12419.]

THE ELECTROMAGNET.[1]

By Professor SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

WE pass on to the researches of the distinguished physicist of Manchester, whose decease we have lately had to deplore, Mr. J. P. Joule, who, fired by the work of Sturgeon, made most valuable contributions to the subject. Most of these were published either in Sturgeon's "Annals of Electricity," or in the "Proceedings of the Literary and Philosophical Society of Manchester," but their most accessible form is the republished volume issued five years ago by the Physical Society of London.

In his earliest investigations he was endeavoring to work out the details of an electric motor. The following is an extract from his own account ("Reprint of Scientific Papers," p. 7):

"In the further prosecution of my inquiries, I took six pieces of round bar iron of different diameters and lengths, also a hollow cylinder, 1-13th of an inch thick in the metal. These were bent in the U form, so that the shortest distance between the poles of each was half an inch; each was then wound with 10 feet of covered copper wire, 1-40th of an inch in diameter. Their attractive powers under like currents for a straight steel magnet, $1\frac{1}{2}$ inch long, suspended horizontally to the beam of a balance, were, at the distance of half an inch, as follows:

	No. 1. Hollow.	No. 2. Solid.	No. 3. Solid.	No. 4. Solid.	No. 5. Solid.	No. 6. Solid.	No. 7. Solid.
Length round the bend in inches	6	$5\frac{1}{4}$	$2\frac{3}{4}$	$5\frac{1}{4}$	$2\frac{3}{4}$	$5\frac{1}{4}$	$2\frac{3}{4}$
Diameter in inches	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{4}$
Attraction for steel magnet, in grains	7·5	6·3	5·1	5·0	4·1	4·8	3·6
Weight lifted, in ounces	36	52	92	36	52	20	28

"A steel magnet gave an attractive power of 23 grains, while its lifting power was not greater than 60 ounces.

"The above results will not appear surprising if we consider, first, the resistance which iron presents to the induction of magnetism, and, second, how very much the induction is exalted by the completion of the magnetic circuit.

"Nothing can be more striking than the difference between the ratios of lifting to attractive power at a distance in the different magnets. While the steel magnet attracts with a force of 23 grains and lifts 60 ounces, the electromagnet No. 3 attracts with a force of only 5·1 grains, but lifts as much as 92 ounces.

"To make a good electromagnet for lifting purposes: 1st. Its iron, if of considerable bulk, should be compound, of good quality, and well annealed. 2d. The bulk of the iron should bear a much greater ratio to its length than is generally the case. 3d. The poles should be ground quite true, and fit flatly and accurately to the armature. 4th. The armature should be equal in thickness to the iron of the magnet.

"In studying what form of electromagnet is best for attraction from a distance, two things must be considered, viz., the length of the iron and its sectional area.

"Now I have always found it disadvantageous to increase the length beyond what is needful for the winding of the covered wire."

These results were announced in March, 1839. In May of the same year Joule propounded a law of the mutual attraction of two electromagnets, as follows: "The attractive force of two electromagnets for one another is directly proportional to the square of the electric force to which the iron is exposed; or if E denote the electric current, W the length of wire, and M the magnetic attraction, $M = E^2 W^2$." The discrepancies which he himself observed he rightly attributed to the iron becoming saturated magnetically. In March, 1840, he extended this same law to the lifting power of the horseshoe electromagnet.

In August, 1840, he wrote to the "Annals of Electricity," on electromagnetic forces, dealing chiefly with some special electromagnets for traction. One of these possessed the form shown in Fig. 7. Both the magnet and the iron keeper were furnished with eye-holes for the purpose of suspension and measurement of the force requisite to detach the keeper. Joule thus writes about the experiments:[1]

"I proceed now to describe my electromagnets, which I constructed of very different sizes in order to develop any curious circumstance which might present itself. A piece of cylindrical wrought iron, 8 inches long, had a hole one inch in diameter bored the whole length of its axis; one side was planed until the hole was exposed sufficiently to separate the thus formed poles one-third of an inch. Another piece of iron, also 8 in. long, was then planed, and being secured with its face in contact with the other planed surface,

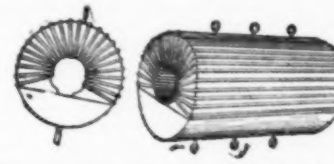


FIG. 7.—JOULE'S ELECTROMAGNET.

the whole was turned into a cylinder 8 in. long, $3\frac{3}{4}$ in. in exterior and 1 in. interior diameter. The larger piece was then covered with calico and wound with four copper wires covered with silk, each 23 ft. long and $\frac{1}{11}$ of an inch in diameter—a quantity just sufficient to hide the exterior surface, and to fill the interior opened hole." . . . "The above is designated No. 1; and the rest are numbered in the order of their description.

"I made No. 2 of a bar of half inch round iron 2·7 in. long. It was bent into an almost semicircular shape, and then covered with 7 ft. of insulated copper wire, $\frac{1}{40}$ of an inch thick. The poles are half an inch asunder; and the wire completely fills the space between them.

"A third electromagnet was made of a piece of iron 0·7 in. long, 0·37 in. broad, and 0·15 in. thick. Its edges were reduced to such an extent that the transverse section was elliptical. It was bent into a semicircular shape, and wound with 19 in. of silked copper wire, $\frac{1}{40}$ of an inch in diameter.

"To procure a still more extensive variety, I constructed what might, from its extreme minuteness, be termed an *elementary electromagnet*. It is the smallest, I believe, ever made, consisting of a bit of iron wire $\frac{1}{4}$ of an inch long, and 1-25th of an inch in diameter. It was bent into the shape of a semicircle, and was wound with three turns of *uninsulated* copper wire, 1-40th of an inch in thickness."

With these magnets experiments were made with various strengths of currents, the tractive forces being measured by an arrangement of levers. The results, briefly, are as follows:

Electromagnet No. 1, the iron of which weighed 15 pounds, required a weight of 2,090 pounds to detach the keeper. No. 2, the iron of which weighed 1,057 grains, required 49 pounds to detach its armature. No. 3, the iron of which weighed 65·3 grains, supported a load of 12 pounds, or 1,286 times its own weight. No. 4, the weight of which was only half a grain, carried in one instance 1,417 grains, or 2,834 times its own weight.

"It required much patience to work with an arrangement so minute as this last, and it is probable that I might ultimately have obtained a larger figure than the above, which, however, exhibits a power proportioned to its weight far greater than any on record, and is eleven times that of the celebrated steel magnet which belonged to Sir Isaac Newton.

"It is well known that a steel magnet ought to have a much greater length than breadth or thickness, and Mr. Scoresby has found that when a large number of straight steel magnets are bundled together, the power of each when separated and examined is greatly deteriorated. All this is easily understood, and finds its cause in the attempt of each part of the system to induce upon the other part a contrary magnetism to its own. Still there is no reason why the principle should in all cases be extended from the steel to the electromagnet, since in the latter case a great and commanding inductive power is brought into play to sustain what the former has to support by its own unassisted retentive property. All the preceding experiments support this position, and the following table gives proof of the obvious and necessary general consequence, the maximum power of the electromagnet is directly proportional to its least transverse sectional area. The second column of the table contains the least sectional area in square inches of the entire magnetic circuit. The maximum power in pounds avoirdupois is recorded in the third, and this, reduced to an inch square of sectional area, is given in the fourth column under the title of specific power.

"The above examples are, I think, sufficient to prove the rule I have advanced. No. 1 was probably not fully saturated; otherwise I have no doubt that its power per square inch would have approached 300. Also the specific power of No. 4 is small, because of the difficulty of making a good experiment with it."

These experiments were followed by some to ascertain the effect of the length of the iron of the magnet, which he considered, at least in those cases where the degree of magnetization is considerably below the point of saturation, to offer a decidedly proportional resistance to magnetization; a view the justice of which is now, after fifty years, amply confirmed.

In November of the same year further experiments[2] in the same direction were published. A tube of iron, spirally made and welded, was prepared, planed down as in the preceding case, and fitted to a similarly prepared armature. The hollow cylinder thus formed, shown in Fig. 8, was 2 feet in length, its internal diameter was 1·42 inch, its internal being 0·5 inch. The least sectional area was $10\frac{1}{4}$ square inches. The exciting coil consisted of a single copper rod, covered with tape, bent into a sort of S shape. This was later replaced by a coil of twenty-one copper wires, each 1-25 inch in diameter and 23 feet long, bound together by cotton tape. This magnet, excited by a battery of sixteen of Sturgeon's cast iron cells, each one foot square and one and a half inch in interior width, arranged in a series of four, gave a lifting power of 2,775 lb.

TABLE I.

Description.		Least Sectional Area.	Maximum Power.	Specific Power.
My own electromagnets	No. 1	10	2090	209
	No. 2	0·196	49	250
	No. 3	0·0436	12	275
	No. 4	0·0012	0·202	162
Mr. J. C. Nesbit's. Length round the curve, 3 ft.; diameter of iron core, $2\frac{3}{4}$ in.; sectional area, 5·7 in.; do. of armature, 4·5 in.; weight of iron, about 50 lb.		4·5	1428	317
Professor. Henry's. Length round the curve, 20 in.; section, 2 in. square; sharp edges rounded off; weight, 21 lb.		3·94	750	190
Mr. Sturgeon's original. Length round the curve, about 1 ft.; diameter of the round bar, $\frac{1}{2}$ in.		0·196	50	255

Joule's work was well worthy of the master from whom he had learned his first lesson in electromagnetism. He showed his devotion not only by writing descriptions of them for Sturgeon's "Annals," but by exhibiting two of his electromagnets at the Victoria Gallery of Practical Science, of which Sturgeon was director. Others, stimulated into activity by Joule's example, proposed new forms, among them being two Manchester gentlemen, Mr. Radford and Mr. Richard Roberts, the latter being a well known engineer and

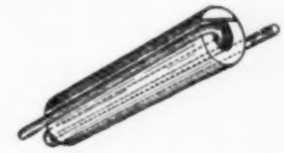


FIG. 8.—JOULE'S CYLINDRICAL ELECTROMAGNET.

inventor. Mr. Radford's electromagnet consisted of a flat iron disk with deep spiral grooves cut in its face, in which were laid the insulated copper wires. The armature consisted of a plain iron disk of similar size. This form is described in vol. iv. of Sturgeon's "Annals." Mr. Roberts' form of electromagnet consisted of a rectangular iron block, having straight parallel grooves cut across its face, as in Fig. 9. This

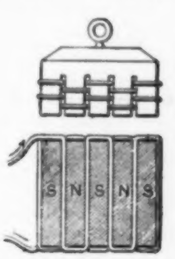


FIG. 9.—ROBERTS' ELECTROMAGNET.

was described in vol. vi. of Sturgeon's "Annals," p. 166. Its face was $6\frac{3}{4}$ in. square, and its thickness $2\frac{7}{16}$ in. It weighed, with the conducting wire, 35 lb.; and the armature, of the same size and $1\frac{1}{2}$ in. thick, weighed 23 lb. The load sustained by this magnet was no less than 2,950 lb. Roberts inferred that a magnet, if made of equal thickness, but 5 ft. square, would sustain 100 tons weight. Some of Roberts' apparatus is still preserved in the Museum of Peel Park, Manchester.

On p. 431 of the same volume of the "Annals," Joule described yet another form of electromagnet, the form of which resembled in general Fig. 10; but which, in

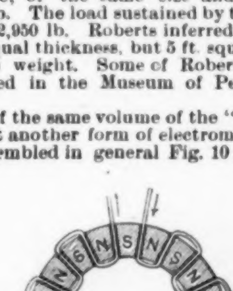


FIG. 10.—JOULE'S ZIGZAG ELECTROMAGNET.

actual fact, was built up of 24 separate flat pieces of iron bolted to a circular brass ring. The armature was a similar structure, but not wound with iron. The iron of the magnet weighed 7 lb., and that of the armature 4·55 lb. The weight was 2,710 lb., when excited by 16 of Sturgeon's cast iron cells.

In a subsequent paper on the calorific effects of magneto-electricity,[1] published in 1843, Joule described another form of electromagnet of horseshoe shape, made from a piece of boiler plate. This was not intended to give great lifting power, and was used as the field magnet of a motor. In 1852, another powerful electromagnet of horseshoe form, somewhat similar to the preceding, was constructed by Joule for experiment. He came to the conclusion[2] that, owing to magnetic saturation setting in, it was improbable that any force of electric current could give a magnetic at-

[1] Lectures delivered before the Society of Arts, London, 1890. From the Journal of the Society.

[1] "Scientific Papers," vol. i., p. 30.

[2] "Scientific Papers," p. 40, and "Annals of Electricity," vol. v., p. 170.

[1] "Scientific Papers," vol. i., p. 123; and "Phil. Mag.," Ser. 3, vol. xxiii., p. 263, 1843.

[2] "Scientific Papers," vol. i., p. 362; and "Phil. Mag.," Ser. 4, vol. iii., p. 32.

traction greater than 200 lb. per square inch. "That is, the greatest weight which could be lifted by an electromagnet formed of a bar of iron one inch square, bent into a semicircular shape, would not exceed 400 lb."

With the researches of Joule may be said to end the first stage of development. The notion of the magnetic circuit which had thus guided Joule's work did not commend itself at that time to the professors of physical theories; and the practical men, the telegraph engineers, were for the most part content to work by purely empirical methods. Between the practical man and the theoretical man there was, at least on this topic, a great gulf fixed. The theoretical man, arguing as though magnetism consisted in a surface distribution of polarity, and as though the laws of electromagnets were like those of steel magnets, laid down rules not applicable to the cases which occur in practice, and which hindered rather than helped progress. The practical man, finding no help from theory, threw it on one side as misleading and useless. It is true that a few workers made careful observations and formulated into rules the results of their investigations. Among these, the principal were Ritchie, Robinson, Muller, Dub, Von Kolke, and Du Moncel; but their work was little known beyond the pages of the scientific journals wherein their results were described. Some of these results will be examined in my later lectures, but they cannot be discussed in this historical *resume*, which is accordingly closed.

(*To be continued.*)

MANUFACTURING SMOKE.*

By GEO. E. DAVIS.

IT has been suggested to me that it is not quite clear what is intended to be meant by the title of our lecture.

One querist has humorously asked whether we intend to treat of smoke manufacturing or manufacturing smoke; but a little reflection will convince any one that the subject will be practically unaltered whether we consider the attribute as adjective or participle.

To treat the word "manufacturing" as a participle would be like "carrying coals to Newcastle." Every one knows how to manufacture smoke. The operation is carried on too well nowadays to require description, and therefore it is well that we should consider the doubtful word as an adjective, and study the title in this light.

For purposes of discussion, smoke may be conveniently divided into two categories, manufacturing and domestic, when it will be found that each class requires treatment from its own special standpoint, and that the remedies proposed for the one will not deal satisfactorily with the other. This is then a very good reason for separating domestic smoke from that produced in manufacturing processes.

In dealing with manufacturing smoke it will suffice to notice that produced from coal and coke; smoke is of course capable of being produced from other substances, and especially from liquid fuel, but the employment of this combustible is by no means general at present, so that "sufficient for the day is the evil thereof."

The combustion of coal as a theoretical study is no doubt very well understood in many quarters, but judging from the large number of senseless and absurd patents that are taken out from time to time, there are evidences that the theoretical study of combustion is often sorely neglected. One would think that whether coal was cheap or dear, the user of it would endeavor to utilize the utmost amount of heat it is capable of giving out, but in practice we find this is not so, and in most coal-burning departments the utmost waste and extravagance prevails.

Most coal users know fully well that the ordinary quality of steam-raising coal will theoretically evaporate from 12 to 14 lb. of water per lb. of fuel reckoned from 212 degrees Fahrenheit, yet it is very rare that one meets with an evaporative efficiency of more than 7 lb., even with boilers of good construction and setting.

It is also well known that in several exhibitions well known boilers, such as those of Messrs. Galloway, have evaporated as much as 11·8 lb. of water from 212° F. per lb. of fuel, yet, when these same boilers are employed in ordinary practice, a much smaller duty is obtained. It is our object this evening to show how this comes about, but first of all it is necessary to show how, in ordinary combustion, smoke is produced, its composition, and the deleterious nature of its constituent or component parts.

Combustible substances ignite and burn at very varying temperatures. If I take some petroleum spirit, you will see that the mere application for an instant of a naked flame causes immediate ignition.

1. (Experiment on petroleum spirit.)

If, however, we treat ordinary paraffin oil in the same way, the liquid will actually extinguish the flame of the taper, instead of taking fire, as in the case of the petroleum spirit.

2. (Experiment with paraffin oil.)

If I now heat the paraffin oil, ignition takes place more easily; as you will see.

3. (Experiment by heating the oil.)

We may next endeavor to ignite a mixture of these two liquids, when you will observe that the high inflammability of the one aids the apparent indifference of the other.

4. (Experiment on mixed liquids.)

You will also have observed, no doubt, that the paraffin oil did not burn with such a smoky flame as the petroleum spirit, and if I now show you the combustion of a liquid containing more carbon, such as benzene, obtained from the dry distillation of coal, you will find that the flame is even more smoky than that of the petroleum spirit.

5. (The combustion of benzene.)

Solids generally, especially those of a semi-mineral nature, require considerably higher temperatures to start the ignition, and this is easily demonstrated by the application of heat to anthracite and graphite.

6. (Anthracite ignition.)

7. (Graphite ignition.)

In the instances I have already shown you, viz., the ignition of several liquids, the formation of smoke can be readily avoided by the proper regulation of the air supply, and the maintenance of the temperature of combustion. It would be rather difficult without the aid of expensive apparatus to show you this in a satisfactory manner, but by using ordinary coal gas, it can be readily exhibited.

8. (Bunsen's burner and Wanzer lamp.)

It will thus be seen that even with the most readily combustible substances, at least two conditions are necessary to avoid the production of smoke. The first is to insure a proper adjustment of the combustible body and air, while the second is to maintain the flame temperature until the combustion has been completed.

These instructions appear very simple, but the carrying of them out on the large scale is by no means such an elementary problem as at first sight appears. We have principally to deal with the combustion of coal, and that often not of the best quality. We will try the application of heat to it.

9. (Ignition of coal by Bunsen and batswing.)

The first application of heat to coal results in the volatilization of the more volatile products, leaving behind the more fixed portion, or what is generally termed coke. This is what takes place when coal is thrown on a red hot fire, either in a factory furnace or in a domestic fire-place, forming pulsations, so to speak, in the combustion process, the emission of smoke being coincident with the commencement of each pulsation.

Roughly, but quite near enough for all practical purposes, one-third of the component parts of coal may be taken as being volatile under the application of a moderate degree of heat and two-thirds remain fixed and only burn and pass off as gaseous products with the air supply properly maintained.

Now it is well known that when ordinary fuel is charged into a red hot furnace, the distillation process occupies but a few minutes, but in that few minutes one-third of the weight of the coal charged in is driven off, while the air supply is tolerably constant; in fact, the large gaseous volume suddenly generated by the distillation of the coal must certainly check the in-flow of air at a moment when more is required.

Moreover, the gaseous portion of coal requires considerably more air for complete combustion per unit of weight than does the fixed portion. An example will perhaps illustrate the matter more clearly:

An ordinary 30 by 7 Lancashire boiler is usually made to burn rather more than 40 tons of coal per week of 132 hours; this amounts to 690 lb. per hour, or 23 lb. per square foot of grate area per hour, reckoning 30 square feet as the area of the grates.

Working under good practical conditions, 220 cubic feet of air will be consumed per pound of coal, so that every hour will see brought into the fire-places $690 \times 220 = 151,800$ cubic feet of air, which is 12,650 cubic feet every five minutes. We will suppose now that the fireman fires the furnaces every half hour, and that he does what I have very often seen done, viz., fire both furnaces of the boiler together. In this case 3 cwt. of coal will have to be thrown on each furnace every half hour. Of this three hundredweights, we have already seen that one-third is volatile and quickly driven off as combustible gas. It may be stated as being accurate enough for all practical purposes that this one-third will be evolved in five minutes, and that the residual two-thirds burn off in the remaining twenty-five. Approximately, then, one hundredweight of the gaseous portion is supplied with 12,650 cubic feet of air, and the two hundredweights of fixed fuel with 63,250 cubic feet. This calculated per pound of fuel is 113 cubic feet per pound for the gaseous portion and 282 cubic feet for the fixed.

I am now speaking of an ordinary boiler, fired by hand and looked after in the best manner, and not overworked; the evil becomes much intensified when more than 40 tons of coal per week is burned under a single boiler. The gaseous portion of the fuel requires far more air per unit of weight than the fixed, yet in practice the reverse is actually obtained. This weak point has been observed and partially corrected by several inventors.

It is not my intention this evening to act as an advertising agent for those enterprising men who have endeavored to solve the smoke problem. Most of them have been invited to attend here this evening, and to exhibit models or drawings or appliances of any special kind they may have designed for lessening or preventing smoke, and no doubt they will be able to explain to you such special apparatus much better than I can do.

My desire is to set forth, in as clear a manner as I possibly can, the broad principles which underlie the problem, so that smoke producers may not spend their capital unprofitably when they endeavor to make a change.

Returning now to our remarks upon air supply, the extra requirements of air at the period when coal is newly charged on to the fires has long been catered for by many inventors. Every one who has written or spoken on the smoke question has for many years quoted Mr. C. Wye Williams, and the Parkes split bridge. The air bridge has been adapted to many boilers, but after a few days' use they are generally inefficient, having in a short space of time become choked up with ashes and flue dust. Moreover, in the hand-fired boiler the extra air is only needed when the volatile products are being so rapidly evolved from the coal; at other times, excess of air is decidedly injurious. It may be urged that most of these air bridges have dampers to open or close them; this is granted, but all I have seen without exception were, when examined, so clogged with flue dust as to be immovable either one way or the other.

Appliances to admit air to the furnace for so many minutes after firing, self-closing after that period, have been devised by several inventors, and are at work in a few mills to my knowledge, that is to say, they are fitted to the furnace doors; more than this I would not care to vouch for.

The official report of the London Smoke Abatement Exhibition, of 1882, contains descriptions of several appliances devised to give more air at the time immediately after firing. Hollow bridges, hollow bars, superheating chambers, and balanced doors, all provided to give more air.

What I wish to point out now is that too much air may be given. In a well fired boiler, stoking by hand, the excess oxygen should not exceed 6·5 per cent. by volume in the products of combustion, when the sample of gas is taken over a long period, say two hours, whereas in a boiler flue I once examined, the furnaces to which were fitted with split bridges and self closing louver doors, the excess oxygen amounted to 13·2 per cent., showing a great loss of heat by the chimney.

It needs specially to be observed that those inventors who have labored to introduce excess air to the furnaces during the period immediately after firing were under normal and well defined conditions working in the right direction.

Those conditions were hand firing and burning say 13 lb. of coal per square foot of grate surface per hour. But 40 tons of coal per week means 23 lb. per square foot of grate surface per hour when applied to an ordinary Lancashire steam boiler, and nowadays a combustion of 36 lb. per square foot of grate surface per hour is by no means uncommon.

The first limit of coal consumption is very seldom exceeded in the tests made at Smoke Abatement Exhibitions, and hence their uselessness. A very indifferent stoker can prevent visible smoke when burning coal at the rate of 13 lb. per square foot of grate surface per hour. It becomes much more difficult at 23 lb., while at 36 lb. smoke prevention is almost impossible, even with the aid of all the legion of smoke-preventing appliances, save mechanical stokers.

The method of testing coals at the Smoke Abatement Exhibition, of 1882, will show us what the engineer of that exhibition imagined to be the proper rate of combustion. On page 141 of that report the Welsh steam coals were burned at the rate of 8·68 lb. per square foot of grate area per hour; Nixon's navigation coal, 11·82 lb.; Northumberland steam coal, 16·73 lb. and 20·87 lb.; and artificial fuel, 11·26 lb.

Complete combustion can only take place when the combustion temperature is maintained. Any influence which tends to lower the temperature, within certain limits, tends also to retard combustion. Time is also a material element, so that when the firing is excessive the partly burnt gases are hurried out of the hot fireplace and brought into contact with the comparatively cool boiler plates, thus causing smoke. In an ordinary boiler, burning 23 lb. of coal per square foot of grate surface per hour, the furnaces have each but a capacity of 21 cubic feet, and as this quantity of air is admitted every second of time, the high pressure of the operation goes without saying.

But the air enters say at a temperature of 70° F., and before it leaves the furnace, or thereabouts, has become expanded to at least four times its original volume, so that not only has the temperature of 2000° F. to be attained in the fourth part of a second, but the space in the furnace above the grate bars must be filled and emptied four times in each second. I have never seen the problem put in this way before, and it will furnish all coal consumers with much food for reflection, and it will also serve to impress upon inventors the necessity of the time element, as against the admission of air only.

Having now shown the necessity of time and the maintenance of the temperature of combustion as applied to hand firing, we may turn our attention to other means that have been designed to overcome some of the difficulties I have already pointed out.

It will naturally have occurred to you at this stage to inquire whether the distillation of the coal into one third gas and two thirds fixed coke could not be carried on simultaneously with the combustion of both of them in fixed and regular quantities, so as to avoid the pulsations already spoken of as smoke pulsations, and to avoid also the irregularity of the air supply, so detrimental to perfect combustion.

This brings us to another stage of the inquiry.

If the coal necessary for any required degree of combustion could be dusted on to the white hot fire in a continuous stream, and in the exact ratio required for complete combustion, everything would go well until the capacity of the furnace for complete combustion is overstepped. Many inventors have endeavored to accomplish this, and many have succeeded in producing very good specimens of what are know nown as mechanical stokers.

There is not time to go into the details of these appliances in the short space of an evening lecture, but, as I have already said, the makers of many of these things have been invited to be present to-night, so that no doubt they will be pleased to explain their contrivances to you.

What I have set myself to do is to bring before you what are considered by many the strong and weak points of mechanical stokers as applied in practice.

The first remark must be a general one, and the good old engineering maxim that "no machine is stronger than its weakest part" bears upon it.

Breakdowns have sounded the death knell of many a mechanical stoker, and in many instances blame has been cast upon the principle of stocking mechanically, when it ought to have been thrown on the constructive engineer. But experience begets perfection, and the lessons of the past have not been disregarded by the inventor of to-day.

The many mechanical stokers are all of them capable instruments in the hands of an ordinary fireman. They feed in the coal regularly, most of them break up and discharge the clinkers, and all of them, when not worked beyond their capacity, give a chimney absolutely free from visible smoke.

If the foregoing statements be true, and it must be admitted they are, why is it that the mechanical stoker is not universally adopted? There are several reasons—the first, that many steam users grudge the extra outlay on the boilers, is sadly too true. Second, many have been led to expect a large per cent. saving in £ s. d., which has not perhaps been realized, and the knowledge of this has led their friends to hesitate in adopting the invention, but, anyhow, the gain is to he public in having a less contaminated atmosphere,

* A recent lecture before the Manchester Technical Laboratory. Reported in the *Chemical Trade Journal*.

and fewer smoke-begrimed buildings to disgrace our public walks.

I am of opinion that a well arranged mechanical stoker will always show a better utilization of heat units from the coal over even the most perfect hand firing, but *cæteris paribus* the difference is not always so appreciable as some inventors would have us believe.

The greatest drawback, however, to mechanical stoking is the fluctuating requirements of the steam user.

In mills merely running a steam engine, mechanical stokers will act admirably, but in the case of bleach works, paper mills, or chemical works and such like establishments, where a small and regular supply is required for several hours together, and then suddenly and without warning the whole steam-raising power is brought into requisition, the mechanical stoker is not suited, unless it be specially arranged.

There is no insuperable difficulty in this, but it is a noteworthy fact that these little arrangements are often not thought of inside the works where they are required until suggested by an outsider. In one works in which all the boilers were so well provided with mechanical stokers that one could not tell whether the factory was in operation or not by a mere inspection of the chimney top, the steam required in large volumes intermittently brought down the pressure in the mains to near 7 lb. per square inch, so that some plant in which I was interested was brought to a standstill.

Some of the workmen began at once to argue against the efficiency of mechanical stokers, not realizing the fact that the stokers were blameless. But this was soon put right by detaching a boiler from the set, for high pressure duty, which, of course, overcame the supposed evil.

A well proportioned and carefully fired Lancashire boiler, whether manipulated by hand or by a mechanical stoker, should allow of the transfer of not less than 80 per cent. of the theoretical heat of the coal to the water when an economizer is used in connection therewith. The heat lost by the chimney gases should not exceed 10 per cent., nor should the loss by unburned carbon in the ashes exceed 2½ per cent.

As I have many times publicly pointed out, the smoke difficulty lies in a nutshell. If the boilers are carefully hand-fired and the coal is burned quietly, say at a rate not exceeding 12 lb. per square foot of grate surface per hour, and with an air supply produced by a chimney draught equal to 220 cubic feet at 62° F. per lb. of fuel, there will be no visible smoke. As we increase the quantity of coal per unit of time over a given area, so we increase the density of the smoke shade until, when all restraint is removed, smoke of Stygean blackness is constantly emitted.

The case I have already put before you, in which the steam pressure in the mains became reduced to 7 lb., is not a matter that could be allowed to happen in every works, and it is doubtful whether it was an economical proceeding in the factory where it was wont to happen. It is, however, not an uncommon occurence, and is a fault that has been considered by the makers of nearly all the mechanical stokers, so that most of these appliances are now provided with independent firing doors, that when a sudden call is made for a large volume of steam, that call may be met by extra hand firing.

Here lies the secret of smoke production where there is a mechanical stoker. A boiler furnace already fired to its full capacity is perhaps suddenly made to burn three times as much fuel as when it was working smokeless, and perhaps with the same supply of air by the chimney. But even suppose that an increased ratio of air be supplied, it would then mean that the furnace would have to be filled and emptied of its gaseous contents not less than twelve times in every second.

If this extra firing is not done, what is the result? Steam down, keirs idle, and the workmen affected engaged in those saintly exhortations so characteristic of the workmen of to-day.

I would not have you to suppose that the mechanical stoker is the only appliance devised to secure freedom from smoke.

The mechanical stoker cannot properly be called a smoke consumer. It is simply an apparatus to feed the fuel into the furnace in a continuous and scientific manner, and to give easy access to the air supply, by breaking up the clinker, causing it to leave the fire bars. It allows of an almost perfect regulation of the air supply, so that much larger quantities of coal may be burned on a given grate area without smoke being produced.

There is a range of boilers working in Liverpool today fitted with a well known mechanical stoker, each boiler burning 1,120 lb. of coal per hour without producing smoke.

Why, then, should visible smoke be allowed in our northern towns?

At this point some of our steam-using friends may be tempted to inquire respecting the merits of undergrate blowers.

Now it is a well known fact that less air is required for combustion per pound of fuel burned when the air is forced into the furnace than when the products of combustion are simply withdrawn by the chimney draught, and it is possible that some day steam users will settle down to the mechanical stoker, combined with an undergrate blower, as the orthodox method of steam raising.

In the Permanent Chemical Exhibition you will see a drawing of a system of undergrate blowers of which I happen to know the details of a recent installation.

Up to the date of the change the boiler was fired with ordinary boiler slack at 12s. 6d. per ton, divided in quantity equal to, say, $45x$ tons, producing y volumes of steam. With the undergrate blowers y volumes of steam are now produced by the combustion of $44x$ tons of dross, costing 3s. per ton, and with the advantage of a smokeless chimney.

The earliest patent for steam raising, in which the prevention of smoke was considered, was taken out by James Watt in the year 1785—just 105 years ago. Have we made any advance in the matter during these 105 years? When I look round the neighborhood of all large manufacturing towns and see the clouds of black smoke issuing from the chimneys, when I observe the smoke-begrimed buildings in our city streets, I am tempted to think that, if our forefathers were worse off than we are now, the "good old times" must have been rare old times indeed.

We may now turn our attention to another system by means of which coal may be burnt smokelessly, that is, by first converting it into gas.

All of you have heard, no doubt, of water gas. Well, no one would think of firing steam boilers with water gas, but what is called "producer gas" may often be, and is, so employed.

Producer gas is a by-product, so to speak, of water gas, but it is also produced as a substantive product in the Siemens, Dowson, or Wilson producers. It is very easy to burn this gas without producing smoke, but though some few have stated that there is a pecuniary advantage in using it, yet I believe that this is so only under special conditions, and under special circumstances.

Producer gas must not be confounded, in any way, with coal gas as we ordinarily know it. The heating powers of the two are very different and must be duly considered.

One pound of coal gas will give out 12,233 units of heat, while a pound of the best producer gas will give out but 1,000 units.

To put it more plainly, 12 pounds of producer gas will not do more heating than one pound of coal gas, even when the producers and the combustion are well managed, while if they are badly managed, gaseous fuel may become a very expensive luxury indeed.

Producer gas is, bulk for bulk, nearly twice the weight of coal gas, so that 6,000 cubic feet of Dowson gas are only equal to 1,000 cubic feet of coal gas, and if, as stated, Dowson gas can be made for fourpence per 1,000 cubic feet, this is equal to using coal gas at two shillings.

The tests made at the Smoke Abatement Exhibition of 1882 with this gas as compared with coal gas show a ratio of 4·17 to 1·0, but I am inclined to the opinion that this is too favorable for general practice.

The industrial application of gaseous fuel seems inclined to receive a fresh impetus through the introduction of Mr. Mond's patented process, in which ammonia is recovered from the products of combustion, or rather from the products of the gasification.

We may now turn our attention to the composition of the gaseous products of combustion, from ordinary coal and coke.

The gases from the flues of a carefully fired Lancashire boiler, not overworked, may be stated as:

Carbonic acid	10·4
Carbonic oxide	Nil.
Oxygen	6·4
Nitrogen, sulphurous acid, etc.	83·2
	100·0

The amount of soot passing away by the chimney averages about six grains in the 100 cubic feet of gases, and the sulphurous acid of the smoke averages, with good coal, 0·8 grain per cubic foot.

This sulphurous acid is an invisible gas, suffocating in its nature to animals, and most destructive to vegetation. It diffuses into the atmosphere, dissolves in the rain, the dews and the mists; it oxidizes into sulphuric acid or oil of vitriol, and does far more damage in its new guise than in its old form; it permeates and rots our picture cords and window curtains, the sash cords of our windows, and the leather bindings of our libraries, spreading destruction around with a very lavish hand.

The deleterious nature of the sulphurous acid contained in the products of combustion from ordinary coal has not been sufficiently recognized by those reformers who have sought to ameliorate our atmospheric conditions.

The sulphuric acid of coal smoke is a far greater evil than that of the black or visible portion, yet it is the black or visible portion that is usually attacked as being the author of so much mischief.

10. (Influence of SO_2 on colors.)

Many recent writers on the smoke question have endeavored to prove that if smoke is totally suppressed much injury will arise from the formation of carbonic oxide; a very deadly gas.

This argument is totally without foundation; in fact, it is false in the extreme, and in a well fired boiler to which sufficient air is carefully admitted, there is no carbonic oxide whatever to be found in the flue gases.

Time is progressing—I think I have already said enough to show that, with proper means, visible smoke will in all cases be prevented.

If steam users will persist in firing their boilers intermittently by hand, they must be satisfied with burning only as much coal as will produce a smokeless chimney; if they desire to press their boilers harder, I have already pointed out the remedy—the mechanical stoker.

So far, I have only considered the smoke arising from steam production, but furnaces of many other kinds also produce smoke.

It is not my intention this evening to enter upon such a vast and varied field. It will be better to leave this for a future lecture, but it may be as well to say that in all cases smoke can be avoided without expense if the producers of it will only put their shoulders to the wheel in the right way.

There is only one thing left to consider, and that is the sulphurous acid of the smoke, so long neglected, and so baneful in its effects. How is it to be suppressed?

Efforts have been made, however, to overcome the nuisance and injury arising from the sulphurous emanations from boiler smoke.

At the Manchester Smoke Abatement Exhibition of 1882, Mr. Benjamin Goodfellow, of Hyde, exhibited the model of a machine, then in operation at his works, washing the smoke from two of his boilers.

A drawing of this apparatus may be seen in the exhibition room.

We asked Mr. Goodfellow if he would be good enough to lend us the model for the purposes of this lecture, but we learned from him that it had been, unfortunately, broken up. We have learned from him, however, that when water was used in the apparatus alone, 75 per cent. to 80 per cent. of the sulphurous acid was removed, while when soda or lime was employed the whole of the sulphurous acid was absorbed.

Mr. Goodfellow says, most pertinently, "The chief advantage which this machine possesses is that it deals with the poisonous part of the smoke, which is *acid.*"

I do not know what has become of this machine, whether it is still in use at Hyde, or whether it has been consigned to the limbo of forgotten things. Perhaps if Mr. Goodfellow is here to-night he will be able to tell us.

The Porion spray chamber is also a very good smoke washer.

It has been designed by us as a smoke washer as early as 1877, and it answers this purpose admirably, far better than any ordinary condenser.

LUBRICATING OILS.

By A. C. J. CHARLIER.

DURING the last few years great improvements have been introduced in the manufacture of lubricating oils.

Looking back some twenty years, we find that the users of lubricants could not be persuaded to use anything but castor or sperm oil, but gradually, from the researches and investigations made by specialists in this class of oils, compounds and carefully prepared mineral oils have been introduced which far surpass the old lubricants both in price and quality. In order to be able to determine the utility of the great number of these lubricants now in the market, and in order to determine the proper lubricant to choose for the different classes of work, it is more than ever necessary for users to become acquainted with easy methods of analysis and examination, as well as to know the nature and general qualities of the oils of which the compounds generally consist.

Before dealing with the oils used for lubrication, it is necessary to consider what constitutes an efficient lubricator.

A good lubricating oil must have sufficient body to keep the surfaces between which it flows from coming into contact, hence the reason why high gravity oils are now so much used on all classes of machinery. But at the same time everything depends on the class of work on which the oil is to be employed. If for light machinery, a very heavy oil would have a tendency to clog the bearings, thus impeding the speed, therefore for all ordinary machinery an oil ranging in gravity from 0·850 to 0·890 should be employed, while for heavy machinery, oils ranging from 0·900 to 0·980 should be chosen.

Another important feature is to obtain oils having the greatest amount of fluidity consistent with body. Many oils are selected because they are apparently of high gravity, but such in reality is not always the case.

The commonest paraffine burning oils can now be given an artificial gravity resembling castor oil, and yet immediately they become heated, even to a moderate temperature, they run off the bearings like water. Many of the Russian mineral oils now on the market have a gravity of about 0·930, are very highly refined, and of a splendid color, and yet when heat is applied they instantly lose their gravity, become limpid, and are quite useless for the purpose for which they are required. But still it must be mentioned here *en passant* that these Russian oils are very useful in making up compounds with oils not affected by temperature, as they then supply body to an oil which, although an excellent lubricant, could not be used for heavy machinery on account of its low gravity.

Another point to be considered is to find an oil with a maximum capacity for receiving and distributing heat, together with a freedom from tendency to gum or oxidize. Hence none of the drying oils should be used for lubricating purposes, and under this head users of lubricants must be warned against a process which has lately been discovered of adulterating lubricating oils with soap, by which is produced a very fine sparkling oil of gravity higher than castor, but at the same time utterly useless for lubrication. Users of lubricating oils often lay far too much stress on the color of the oil, but with many methods now known of giving any oils, good or indifferent, any color, either ruby, golden or black, by the addition of the smallest percentage of the many aniline colors soluble in oils, the color should no longer be taken as a test of quality, all that is required being that the oil should be bright and free from insoluble matter. It is essential that a lubricating oil should be neutral—that is, it should neither be acid nor alkaline. In the refining of many kinds of oil, mineral acids and alkaline earths are used, and, especially in the cheaper oils, sufficient care is seldom exercised in washing them free from all traces of acid. And then, again, it is well known that manufacturers often leave a large portion of alkali in the oils, as this greatly helps to make up their gravity.

Having now dwelt on what are the requirements of a good lubricant, the next step will be to describe several ready tests by which the utility of the oils can be quickly determined. Not tests and analyses which can only be worked by competent chemists, but ready methods which can be employed by any ordinary user of machinery. With regard to the gravity, this is an essential step, and in order to find this, we have gravity bottles, Sprengel's tubes, etc., all of which necessitate the use of a balance. The simplest method is therefore to use an ordinary hydrometer. The oil is placed in a cylindrical glass vessel, and the hydrometer floating in the oil marks immediately the gravity, taking water as 1,000. This method is very useful, because the gravity of the oil can be determined at any temperature, while by the more complicated methods it is very difficult to determine the gravity at any other temperature than that of the ordinary atmosphere. But with the hydrometer the glass vessel can be heated in a water bath, and the gravity taken by placing the hydrometer in the oil at any moment. By this means it can be seen if the sample retains its original gravity when heated.

The "flashing point" of an oil is understood to mean the temperature at which the escaping vapor will momentarily ignite. The standard animal and vegetable lubricating oils, and all mineral oils of good body and high gravity, decompose or vaporize only at temperatures exceeding that of steam in ordinary engines, but nevertheless many of the lubricating oils now in the market are so worthless that it is very essential to

know a ready means of ascertaining their flashing point.

Many very good forms of testers, such as Abel's, Bernstein's, or Bailey's, are used, and they are all more or less on the same plan, namely, consisting of a metal receptacle for containing the oil surrounded by a water bath, with a lamp for heating the bath. The vessel containing the oil is closed, with the exception of a small aperture through which the vapor ascends. A small gas jet is continually played over this aperture, and instantly the vapor flames the temperature is noted, this constituting the flashing point of the oil. But all these testers require very careful manipulation, and the writer therefore suggests a simple apparatus, which can be worked very easily, and at the same time gives very accurate results. A small glass beaker is fitted into a larger one by means of a cork or India rubber band. The former is to contain the oil, the latter serves as a water bath. The smaller beaker is closed at the top by means of a cork, through which is inserted a thermometer dipping well into the oil, and a small piece of glass tubing tapering to a point, through which the vapor ascends. The oil should be on exact level with the water in the outer vessel, so that the same pressure exists in both vessels, and when an oil to be tested is supposed to have a flashing point above that of boiling water, an oil bath should be used in place of water. Everything being ready, the apparatus is stood on a sand bath, under which is placed a spirit lamp, and gradually heated. A lighted taper is applied continually to the aperture through which the vapor from the oil is ascending, and immediately a small blue flame appears the temperature is noted, and the flashing point of the oil under examination thus determined. Any oil having a flashing point below 300 deg. Fah. should be at once discarded as useless.

Another very important test is the viscosity or fluidity of an oil, and here again we have some very elaborate apparatus recommended to us, but an engineer is in want of ready and quick tests, not such as would take him perhaps a day to work out, but one that can be worked in a few minutes, and at the same time give him accurate results. A very simple and general test of fluidity is to dip blotting paper in the oil and hold it up to drain. Symmetrical drops indicate good fluidity, a spreading tendency viscosity. Again, an ordinary glass tube having a diameter of half an inch, tapering to a point at one end, and marked into divisions of 1 in., will answer all ordinary purposes for testing the viscosity of an oil. The oil to be tested is placed in this tube up to a given mark, and is then allowed to run out at the tapered end of the tube, and the time taken is noted. This is compared with the time taken by standard oils previously ascertained in the same tube, and thus the viscosity of the oil can be determined. Sometimes it is necessary to take the viscosity at different temperatures, and in this case the glass tube can be fitted into an outer jacket containing water heated up to the required temperature. For all light machinery running at high speed, low gravity oils having a low fluidity should be looked for, while for heavy machinery of all kinds high gravity oils, with a moderate fluidity, should be employed.

An oil evaporating more than 5 per cent. in twelve hours, at a temperature of 140 deg. Fah., is useless, as the evaporation creates a viscous residue, or leaves the bearings dry. To test for this, a weighed quantity of the oil should be placed in a porcelain dish and heated for the requisite time, then cooled and weighed and subtracted from the original quantity. The difference in weights constitutes the loss by evaporation.

The best lubricating oil is that which has the greatest adhesion to metallic surfaces, and the least cohesion in its own particles, and bearing this in mind, there is no doubt but that mineral oils come first, sperm oil second, neatsfoot oil third, and lard oil fourth. Hence the finest mineral oils are best for light bearings and high velocities, and to give body to mineral oils fine sperm oil is used, or when greater tenacity is required, lard and neatsfoot oils may replace sperm oil, and for the heaviest machinery mineral oils alone cannot be recommended, on account of want of body and higher degree of inflammability.

At the present time, it is not so much a matter of quality which troubles the engineer, but it is the question of cost. Lubricants answering in every way what is required of them can be obtained, but their cost is far too high for the ordinary consumer, and it therefore necessitates producers to search for compounds which will give to cheap oils the same properties as sperm, lard, etc., and be able to sell them at about half the price.

Mineral oils are the cheapest lubricants known and yet they are often discarded for one reason, because they do not possess the same body as many of the vegetable and animal oils, and hence require a larger quantity to be used to do the same work. But, if double the quantity of mineral oil is required to do the work done by other oils, the price of the former is only one quarter that of the latter. Hence the mineral oils are still by far the most profitable to be used.

Oleate or stearate of alumina is now greatly used for giving a body to light gravity mineral oils. It is a very cheap compound, and can be added at a very small cost. The production of this "metal soap," as it is called, is well worthy of consideration, and can be well classed as a very successful issue to a lot of research work recently done by several chemists in endeavoring to produce cheap lubricants. The high class animal and vegetable oils in such high favor among engineers for their lubricating powers consist principally of olein and stearin, and these two substances, which give to these oils their high lubricating powers, can now be introduced into cheap mineral oils, thereby converting them into the finest lubricants at a cost far below that paid for castor, sperm, and such like oils. The oleic and stearic acid is obtained in the usual way from any of the oils rich in olein and stearin and is then precipitated with alum in the presence of caustic soda, thus forming oleate and stearate of alumina. A very small percentage of this metal soap dissolved with warming in light gravity mineral oils will increase their gravity some 50 or 60 deg., will greatly improve their lubricating properties, and after filtering through fine copper gauze, will give them a brilliancy not surpassed by any of the finest animal oils in the market, and at the same time not increase their cost of production more than 20s. per ton.

Some manufacturers use now a process of thickening their oils with ordinary soft soap, but this adulteration can be easily detected by adding glacial acetic acid and warming, when the soap will at once separate out. The writer recently examined a very fine-looking sample of lubricating oil, resembling in appearance castor oil, and found on estimation that as much as 60 per cent. of soap had been introduced into the oil. Any oil found to contain such soap should be at once rejected.

Lardine and blown rape oil are now also largely used for giving body to lubricating oils. The former consists principally of cotton oil, which has been heated in the presence of a strong blast of air, somewhat similar to the process employed for thickening linseed oil, while the latter consists principally of colza oil treated in a similar manner. The presence of these "thickeners," as they are termed in the trade, cannot be said to visibly deteriorate the lubricating powers of the oil with which they are mixed; but they certainly do not improve it, and unfortunately they quickly become dull and cloudy, and in order to prevent this resin oil must be used in conjunction with them. A small percentage, say 1 per cent., of resin oil does not deteriorate the lubricating properties of an oil, but one containing above this percentage cannot be recommended for lubricating purposes. The presence of resin oil can be detected in mineral oils by treating a small portion of the sample with an alcoholic solution of caustic soda, heating on a water bath and evaporating nearly to dryness, then add a large quantity of distilled water and boil for some time, when a milky liquid will be formed; now add more water and warm, and notice the color of the oil that separates out. If clear, then mineral oil is only present, a brown color denoting the presence of resin oil. As a confirmatory test, draw off the aqueous liquid from beneath and make it acid with sulphuric acid. If no precipitate, the oil was all mineral, as a precipitate collecting on warming in brown viscous drops confirms the presence of resin oil. But now, if instead of a milky liquid a semi-frosty mass is obtained after having added the distilled water to the evaporated solution, a fatty oil is evidently also present with the mineral and resin oil. Add more water, when the mineral oil will float to the top if present. Now draw off the aqueous liquid and shake it up with amylic alcohol. If the alcohol separates in a brown layer, resin oil is present. Again draw off the aqueous liquid, acidulate with hydrochloric acid, and warm, when the separation of oleic acid, with its characteristic odor of fat, will show the presence of a fatty oil, either lard, neatsfoot, or cotton oil.

For the lubrication of bearings of the largest size, on which, either from the weight of the shaft or fly-wheel, or from the drag of belts or ropes or from the formation of the bearing, very great pressure per square inch has to be resisted, castor oil up to the present appears to have no equal; and, in order to keep such bearings cool, it is very essential that this oil should not be adulterated. The adulterants to be looked for in castor are principally lard oil and colza, and they can be at once recognized by its density. The specific gravity of castor oil is 0·960, lard oil, 0·916; rape oil, 0·912; therefore if the gravity is below 0·955, this alone proves the presence of one of these oils. Again, another very characteristic test of castor oil is by the addition of zinc chloride. If pure, it becomes yellow; if lard oil be present, it becomes milky; and if colza be present, a green coloration is obtained.

Again, sperm oil is still very largely used by the leading cotton spinners, and the reason for this is that it leaves no stain and does not thicken by age or friction. Here again, on account of the high price of this oil, it is often adulterated, and generally with seal oil, cotton and mineral oils. These adulterants can also be easily detected with zinc chloride; if pure sperm oil, a milky solution is obtained, and when adulterated with any of the above mentioned oils, a brown coloration is obtained.

This article would not be complete without noticing the qualities of tallow as a lubricant, and there is no doubt but that, while in every case hydrocarbon oils are safer, and in the majority of cases are better and cheaper lubricants than tallow, even of the best quality, there are a number of cases in which engineers, although fully alive to the trouble and danger which are inseparably connected with the use of tallow, are constrained to use it, having failed to find any sufficient substitute. The great fault with tallow is that it corrodes metal, and often leaves a kind of deposit; and, again, it almost always contains free acids, as much as twenty-five per cent. of free fatty acid having been found in a sample of town tallow. Large proportions of free acid are apt to be due to the tallow being adulterated with wool grease acids, or stearic acid from cotton seed oil. Tallow, again, frequently contains more or less water, infusible matters, and mineral impurities, and has been often purposely adulterated with starch, China clay, whiting, etc. For the detection of these mineral impurities, a small sample of the tallow should be dissolved in petroleum spirit, filtered, the residue washed with a little ether, and dried at a moderate temperature. Boil the residue in water and add iodine. A blue coloration is obtained, proving the presence of starch; again, any effervescence of the residue on addition of hydrochloric acid proves the presence of whiting.—*The Engineer, London.*

FIG. 1.—VIEW OF AN ESTABLISHMENT FOR RAISING POULTRY BY ARTIFICIAL INCUBATION.

ARTIFICIAL INCUBATION.

THE raising of poultry, according to the ascending march of general progress, no longer resembles what it formerly was. The poultry yard was the natural accessory of the farm; the hen sat upon her eggs in some out of the way corner, led her chicks to the neighboring field and brought them back to the farm again in the evening.

Now we practice *aviculture*—a rational, scientific method of poultry raising in harmony with intensive culture and with modern industry.

In the country aviculture has become a genuine industry, which is as important and lucrative as the manufacture of food products or furniture.

Capital is raised for the establishment of this industry just as one founds a spinning mill, and the enterprise is carried on upon scientific lines and according to the experience of the large model establishments.

Aviculture has its special organs, which keep breed-

FIG. 2.—VIEW OF AN ESTABLISHMENT AT MANTES.

ers posted upon all innovations and improvements. In a word, aviculture has indeed become a profession. As such it merits study under every aspect and in its least details.

The most interesting part of this agronomic science is indisputably artificial incubation. Some details and explanatory figures that we have borrowed from Mr. Voitellier's interesting work entitled "Artificial Incubation and the Poultry Yard," will inform our readers as to the different phases that this important operation follows. Incubation is, among birds, the action of sitting upon eggs, and is a natural function of these animals.

The knowledge of the attention to be given in natural incubation has been perpetuated in the country by a

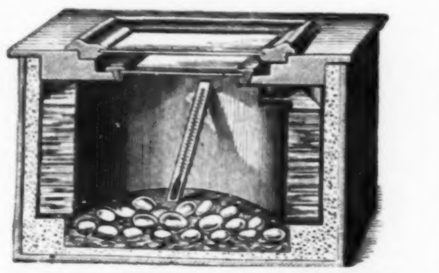


FIG. 3.—SECTION OF AN INCUBATOR.

continuous tradition, and all farmers are in possession of it without ever having studied any book. But simple production, in the natural way, became inadequate, and just as it became necessary to substitute the plow for the spade, just so it became necessary to find a means of increasing the number of animals for feeding a population that is ever increasing, and that has become more exacting in its tastes, and, as the demand kept ever increasing, an endeavor was made to expedite matters by turning out chickens by steam. The *artificial hatcher* was invented. The hen when sitting ceases to lay. This is so much loss to the housewife, and that is why the duty of incubating is sometimes confided to the turkey, which acquits itself of it very well. But an endeavor has been made for ages to substitute artificial for natural heat. In Egypt chickens are "manufactured" in the furnace. The Chinese, also, have had a method of this nature for centuries. Reaumur tried the thing a long time ago, and his memoir upon chicklings and artificial mothers, as well as the experiments that he made, are full of interest. With boxes heated by fresh manure in fermentation, and by

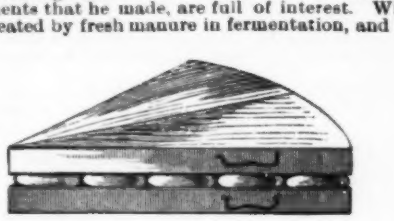


FIG. 4.—EGG TURNER.

dint of attention, he succeeded pretty well. After Reaumur, Bonnemain tried a thermo-siphon that heated the eggs underneath. Afterward came Cautelo, who was the first to heat the eggs on top. Charbogne, also, constructed an incubator, but a mystery was made of the invention and little attention was paid to it. Finally the Carbonnier incubator was shown, and was regarded as one of the best, but until then there was nothing well known, industrially speaking.

It was from the practical science of natural incubation that the inventors of the incubator derived their first ideas. These were the primitive and fixed data that guided them in their first experiments. They did not even invent, but merely imitated nature, and copied her as faithfully as possible. The general principles remain the same, but the inconveniences inherent to natural incubation have been avoided.

Owing to the simplicity of the incubating apparatus, the care and operating of it can be confided to unskilled hands. No more eggs broken during the hen's sitting, and no more chicks crushed at the moment of hatching, or poisoned by mites and the fetid emanations of the nest. There is nothing to offend the senses

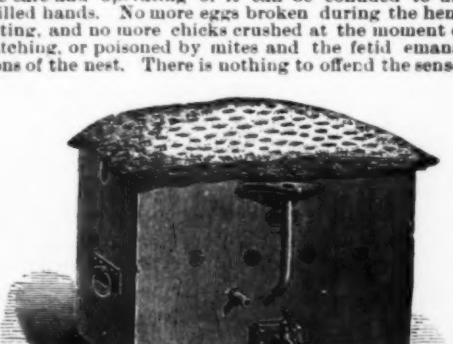


FIG. 5.—WARMING APPARATUS.

of sight and smell, and, in a word, we have success at all times and in all seasons. The care to be taken is limited to the heating of a little water in the morning and evening, and to turning the eggs over. The farmer's wife can run her incubator herself without repugnance.

It is not only on the farm that the incubator may render great services. Hunters may consider its invention as a benefit. They have only to put the apparatus in the hands of their gamekeeper, and unless some accident chances to change the course of its hatchings, they can be certain that their woods will always be full of pheasants at the right time.

The advantage is still greater in the hatching of partridges. Mowers almost always bring in eggs which are in course of incubation, and which are often near the point of hatching and can scarcely withstand a few hours of cooling. Then the gamekeeper runs to all the farms in the neighborhood to look for a sitting hen, and in most cases he brings back a big Cochin China, which, with her heavy feet, crushes the brood. The incubator is always ready to receive the eggs as soon as they come from the field, and all the little ones come into the world without accident.

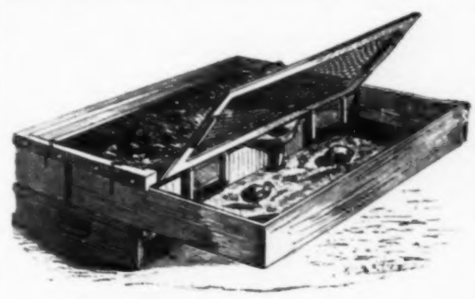


FIG. 6.—ARTIFICIAL MOTHER.

After the hatching the artificial mother is there too to take better care of her chicks than the best of hens do. In a word, the incubator is a practical apparatus that every poultry raiser or intelligent hunter ought to possess.

The following is what has been said by Mr. Joubert, president of the National Agricultural Society, about the incubator that we propose to describe the construction and operation of.

This incubator is so much the more remarkable in that it differs essentially from any that has hitherto been constructed. It is not a laboratory apparatus, it is not one of those complicated devices that, in order to be successfully applied, require an apprenticeship and men who are skilled and especially familiar with the mechanism of the machine to be operated.

This incubator is entirely another affair; it is a true farm apparatus, as strong and as homely as a plow or a churn. It can be intrusted to the hands of a country woman, or of a servant of the brusquest manners, without any fear that the apparatus will suffer from it in its operation. Here there are no drawers to be gently opened, to be examined with precaution and to be closed in the same way. There is nothing fragile, there is no glass tube to indicate the level of the water within, and there is no arrangement that can get out of order through the daily service of the incubator. Everything is visible—everything is done, so to speak, in the open light. The only instructions to be given to the servant in charge is how to read the divisions of the thermometer.

This apparatus (Fig. 3) consists of a wooden box of cubical form containing a zinc reservoir. This latter, which is circular and has double sides, leaves quite a wide space in the center of the box, wherein the eggs are arranged as in a nest. This space is covered with two glazed frames, through which, without anything being opened, the eggs and thermometer may be watched. The heat is derived from the hot water contained in the reservoir (which is surrounded by firmly packed sawdust), and is kept up regularly by the changing of a small portion of the water in the morning and evening.

The aeration, which is almost sufficient through the great volume of air contained in the warm chamber, is kept up by two small pipes that start from the bottom of the box, run along the reservoir, and end at a slight height above the eggs.

The regular humidity is distributed by a layer of sand of one or two inches in thickness, which is placed in the bottom of the incubator and is kept constantly damp. The eggs rest either upon a bed of cut straw covering the sand, or in movable holders (Fig. 4). The use of these holders, called egg turners, presents great advantages.

In consequence of the position they occupy, the eggs do not come into contact with the metal, and receive no heat beneath or at the side. They are heated only by the calorific rays, which, starting from the circular reservoir, converge toward the center and give the same heat as the hen when she is sitting upon her nest. In consequence of the circular form the heat is exactly distributed to every point.

As all the eggs of the incubator are submitted to an

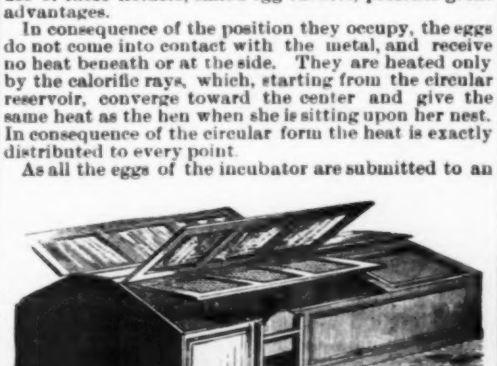


FIG. 7.—GLAZED ARTIFICIAL MOTHER.

equal temperature, it is useless to change their place during the hatching process. It merely suffices to turn them over, as the hen does when she enters her nest after seeking food. These regular and general conditions of temperature, aeration, etc., absolutely replace the hen and constitute the principal elements of success of the incubator.

The warmer (Fig. 5) is a box of rectangular form provided with a hot water reservoir, which furnishes the chicks with a mild and not so high a temperature as they are submitted to in the incubator. This apparatus is covered with soft eider down, and the chick rests as comfortably therein as under feathers.

For partridges and pheasants or for chickens of delicate race the apparatus shown in Fig. 6 is used. The eider down of this, held by a wooden frame, cannot be lifted under the effort of the birds. The apparatus is provided in front with a promenade covered with lattice work.

The artificial mother (Fig. 7) consists of three parts. The first is a movable floor upon which the chicks rest. As this is covered with a thin stratum of fine straw or fine sand it is easily cleaned. The second part is a wooden inclosure which keeps the chicks indoors, and is provided with three doors, one of which is grated to allow of the ingress of air. The third and principal part is a zinc reservoir fitted into a wooden box. The top and sides are provided with a thick layer of sawdust in order to prevent the loss of heat, and the bottom is covered with soft, silky velvet. The chicks, on passing through the little doors, take refuge under the velvet, which being in contact with the reservoir filled with boiling water, is constantly warm and transmits a moderate heat to them, and at the same time smooths their down as well as the maternal wing would.

For the winter or open air raising of pheasants and game, there is also used a glazed artificial mother. The birds have here a large space for exercise under shelter when it rains or when it is cold. If the weather is fine, air is given them by raising the glazed sashes. As the chicks or pheasants are confined by grated frames, they cannot fly away. Doors at the sides and extremities of the apparatus give liberty to the chicks as soon as they grow large.

If, with the artificial mother, we are in possession of a glazed apparatus, we can leave the young birds much longer outside, and, owing to the constantly renewed air, the chances of success increase in a notable proportion. So then, with a relatively small plant, attentive care, and a little surveillance during the first days of incubation, we may have a poultry yard with less risk than formerly, when multiple precautions were necessary for bringing about a good result.

Incubators are being constructed which give, on an average, from 230 to 240 chicks every 21 days, and the smallest give from 40 to 50.—*Le Genie Civil.*

ARTIFICIAL INCUBATION IN EGYPT.*

Report by Consul-General CARDWELL, of Cairo.

SOME days ago I was reading in an American journal the story of two adventurers' exploits in pursuit of fortune in a mining region of New Mexico, and it suggested to me the fact that just now is the height of the season for fowl production in Egypt by a method similar to the New Mexican attempt—artificial incubation. In a late report upon Egyptian industries reference was made to this subject, but therein I simply presented results, intending at some other time to furnish details. With this object in view I went first to the village of Ghizeh, not far from Cairo, but there I found the only incubatory in the place damaged, and therefore not in operation.

A week later I went into the district of Abbasseeyeh, north of the great city, and had the good fortune to find a very respectable establishment in full operation. Though I had never seen one before, I recognized the incubatory in the distance by its six heat escapes rising slightly above the structure, and directed the hackman's course toward it. But on reaching it not a visible sign of life of any sort was discernible. There was a door in one corner of the structure, and a window not far away, both of which were closed with heavy wooden shutters, and the former was locked from the inside. Loud calls from the hackman and from my cavass failed to arouse any evidence of human existence thereabout, and, had it not been for an open sesame move by the latter exercised upon the window, the mysteries of the inner chambers of the egg-hatching establishment would not that day have been unfolded to the writer of this report.

Entering by the opening, it was not long before the door sprang on its hinges. A young Egyptian, followed by my indefatigable attendant, appeared, and in a few moments I was amid dark passages, peering into huge brick ovens or chambers, in which were tens of thousands of eggs, and in two of which were thousands of little chickens just from the shells and not yet able to look after food. In a recess there was the remnant of the last batch of a few days before—four or five hundred active, healthy, vigorous chicks not yet marketed.

Artificial incubation is by no means a strictly modern industry in Egypt. The art of hatching eggs by other than natural process was known and practiced by ancient Egyptians, and the Egyptian incubatory of to-day is but a reproduction of the one of thousands of years ago. In all these years the Egyptian breed of chickens has not changed, and the manner of reproduction has remained immutable. Not long ago I secured the metal stamp of a chicken deposited in a tomb over two thousand years ago, and it is the perfect type of the Egyptian fowl of to-day; and when this stamp was struck, artificial incubation was a thing of actual existence in Egypt. The methods of hatching eggs by artificial means and a knowledge of constructing appliances for the same have descended through ages from father to son, and the wonderful success attending this industry throws into insignificance the modern scientific machines lately introduced into the United States and elsewhere.

The marvelous success of artificial fowl production in Egypt proves the fact that inventive genius, even in America, might be directed into more successful and far less expensive methods of industry by drawing inspiration from these patient, never-tiring people of the Nile valley. In 1880 the fowl industry of the United States amounted to over $200,000,000, and if to so vast an industry could be applied the economies of Egyptian production, profits would be trebled. These economies are exercised in everything. Not only are eggs put through the process of incubation more cheaply than anywhere else in the world, but chicks are reared at an expense past comprehension, while disease and natural death among fowls, because of tireless care, are almost unknown.

The incubatory is constructed of sun-dried bricks, mortar, and earth. The one examined by me was a structure 70 feet long, 60 feet wide, and 16 feet high.

* From reports from the consuls of the United States.

It is provided with 12 compartments, or incubators, each capable of holding 7,500 eggs, making a total capacity of 90,000 eggs undergoing incubation at one time.

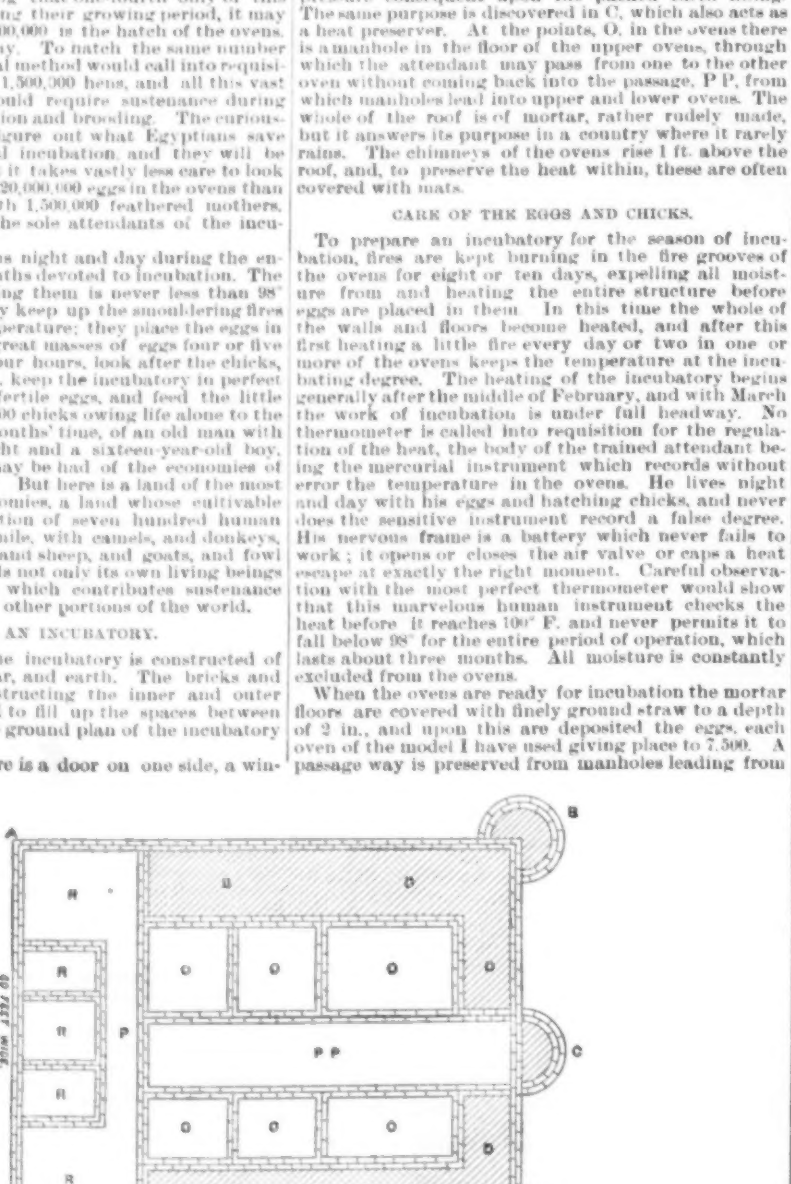
The season of operation lasts only three months out of the twelve, beginning with March and ending with May. Therefore, allowing three weeks for incubating the eggs and one week for removing each hatch and preparation for again filling the incubators with eggs, the number of eggs under treatment at this incubatory in one season may be placed at 270,000. From these are hatched 234,000 chicks. The percentage of hatch would be much greater, but the eggs, being necessarily procured in large quantities and from distant places, are largely damaged for incubation. Still, those lacking vitality are not lost. Experience makes the attendants of the incubators great experts, and in a very few days after the eggs are placed in the ovens the trained hand detects as quickly the unvitalized egg as does the expert bank cashier the defective coin. The unvitalized eggs are at once placed upon the market at low prices for culinary consumption. Eggs are bought for the incubatory at never exceeding 5 cents per dozen, and chicks just from the shell are sold at less than 15 cents per dozen.

After the incubators begin to turn out their product people come from all the surrounding region, buying up the hatch in numbers to suit and disposing of eggs in exchange for chicks. The latter, distributed everywhere, are then reared, with a very small percentage of loss, for sale in the markets. The oven crop of marketable chickens is estimated at 15,000,000 in one season, and calculating that one-fourth only of this crop of chicks die during their growing period, it may be asserted that 20,000,000 is the hatch of the ovens. Here is a huge economy. To hatch the same number of chicks by the natural method would call into requisition the patience of 1,500,000 hens, and all this vast number of mothers would require sustenance during two months of incubation and brooding. The curiously inclined are left to figure out what Egyptians save in resorting to artificial incubation, and they will be surprised to think that it takes vastly less care to look after the incubation of 20,000,000 eggs in the ovens than would be required with 1,500,000 feathered mothers. One man and boy are the sole attendants of the incubatory I explored.

They live in the ovens night and day during the entire period of three months devoted to incubation. The temperature surrounding them is never less than 98° F. This man and boy keep up the smouldering fires that create this temperature; they place the eggs in the ovens, move the great masses of eggs four or five times during twenty-four hours, look after the chicks, deliver them to buyers, keep the incubatory in perfect order, sort out the infertile eggs, and feed the little chicks. Think of 234,000 chicks owing life alone to the tender care, in three months' time, of an old man with most defective eye sight and a sixteen-year-old boy, and some conception may be had of the economies of the Egyptian industry. But here is a land of the most incomprehensible economies, a land whose cultivable area sustains a population of seven hundred human beings to the square mile, with camels, and donkeys, and horses, and cattle, and sheep, and goats, and fowl for all; a land that feeds not only its own living beings dependent on it, but which contributes sustenance valued at $65,000,000 to other portions of the world.

PLAN OF AN INCUBATORY.

As already stated, the incubatory is constructed of sun-dried bricks, mortar, and earth. The bricks and mortar are used in constructing the inner and outer walls, and earth is used to fill up the spaces between them. Herewith is the ground plan of the incubatory explored by me.



At the corner, A, there is a door on one side, a window on the other, with close wooden shutters for both. There are five rooms, R, the first being a sort of reception room provided with a raised mud divan covered with rush mats. Here the buying and selling go on; while the mysteries of the incubators or ovens are neither seen nor understood by the vulgar horde present at stated intervals simply to sell eggs and to buy chicks. The passage, P, leads from this room past others, into which doorways open to another corresponding to it, except that the latter has no openings leading to the outside. In one of these rooms is stored refuse finely ground straw, used for creating the fibers in the ovens. In one of the small rooms the ever present donkey is lord of its floor and walls, while in the others there are a few apparently castaway things. Everything in them—donkey, straw, etc.—is not worth $25. All the walls rise to the same height, 16 ft., and throughout the structure they are 2 ft. thick. By this I mean the brickwork, which I have represented in the plan in a manner which I hope will convey the idea of masonry. The spaces between brick walls, D, are filled with dirt, rising as high as the walls. Passing through but little more than a manhole at P, over which closes a wooden shutter, the passage leading between the ovens is reached. This is 50 ft. long, walls rising perpendicularly on each side to the roof. It is 6 ft. wide. The ovens, O, square rooms, 12 ft. each way, are surrounded by brick walls, which begin to narrow when about 8 ft. high, gradually drawing together until they form heat escapes or chimneys only 10 ½ in. in diameter at their apexes, 1 foot above the roof. Each partition, O, gives space for two ovens, or incubators, 12 by 12 ft. each. One of the ovens is on the ground floor, the others 4 ft. 6 in. higher, on a mortar floor supported by wooden sleepers. This mortar floor is from 6 to 8 inches thick. In the floor of each oven, close to the walls, and extending all around, is a groove moulded in the mortar. It is about 8 in. wide, 4 or 5 inches deep, and in this groove the finely ground straw is burned, producing the heat which penetrates floors and walls, and which creates and maintains the temperature necessary for incubation. When once heated the incubatory is made to maintain the requisite temperature with but little more expense of labor and fuel. From the inner part of the outer walls of the ovens to the outer part of the outer walls of the incubatory is more than 10 ft., composed of brick walls and packed earth. The solidity and thickness of such construction creates a body which not only maintains heat when once imparted, but which thoroughly protects the ovens against outside atmospheric changes.

The parts, D, represent the spaces between brick walls filled with packed dirt. The corner structures, B, are braces to aid the brick walls in sustaining heavy pressure consequent upon the packed earth filling. The same purpose is discovered in C, which also acts as a heat preserver. At the points, O, in the ovens there is a manhole in the floor of the upper ovens, through which the attendant may pass from one to the other oven without coming back into the passage, P P, from which manholes lead into upper and lower ovens. The whole of the roof is of mortar, rather rudely made, but it answers its purpose in a country where it rarely rains. The chimneys of the ovens rise 1 ft. above the roof, and, to preserve the heat within, these are often covered with mats.

CARE OF THE EGGS AND CHICKS.

To prepare an incubatory for the season of incubation, fires are kept burning in the fire grooves of the ovens for eight or ten days, expelling all moisture from and heating the entire structure before eggs are placed in them. In this time the whole of the walls and floors become heated, and after this first heating a little fire every day or two in one or more of the ovens keeps the temperature at the incubating degree. The heating of the incubatory begins generally after the middle of February, and with March the work of incubation is under full headway. No thermometer is called into requisition for the regulation of the heat, the body of the trained attendant being the mercurial instrument which records without error the temperature in the ovens. He lives night and day with his eggs and hatching chicks, and never does the sensitive instrument record a false degree. His nervous frame is a battery which never fails to work; it opens or closes the air valve or caps a heat escape at exactly the right moment. Careful observation with the most perfect thermometer would show that this marvelous human instrument checks the heat before it reaches 100° F. and never permits it to fall below 98° for the entire period of operation, which lasts about three months. All moisture is constantly excluded from the ovens.

When the ovens are ready for incubation the mortar floors are covered with finely ground straw to a depth of 2 in., and upon this are deposited the eggs, each oven of the model I have used giving place to 7,500. A passage way is preserved from manholes leading from the passage way into the ovens to the manholes connecting the lower and upper ovens, and the eggs are not brought into dangerous contact with the fire grooves around their sides. Laid two or three deep upon the straw, the eggs occupy the floor of the ovens between the central manholes and the fire grooves, and four or five times in twenty-four hours are agitated by the attendant shifting them 8 or 10 inches at a time from right to left around the entire circle. This movement is made with apparent carelessness, dozens of eggs being changed in position by a single move of the hand, and yet a single egg among thousands is rarely cracked in the operation. For three weeks this treatment continues, and then, presto! the contents of an oven are changed from a white inanimate mass to a living, stirring, struggling host of chicks, ten thousand of them not making as much noise as a single brood under a hen. The little things are handled most tenderly, the shells being removed from the ovens as rapidly as the chicks emerge from them. Left for several days in the warm ovens, over the floor of which food is scattered for them, they gain rapidly in strength. But they are also taken away very rapidly by dealers and those who desire to raise chicks for the market, and even a remnant of a hatch does not remain many days about the incubatory. When the chicks are not at once sold, the extra rooms about the establishment are brought into requisition for their care until they are disposed of. The ovens are so charged with eggs as not to have them all hatch at the same time. Two ovens generally turn out crops of chicks on the same date, and in a few days come those two others. The operation of hatching is closely consecutive throughout the season. Eggs of other fowls than the common chicken are rarely hatched except by the natural process of incubation, and I do not pretend to convey the idea that a very large percentage of chickens are not produced in Egypt by nature's process.

COST OF CONSTRUCTION.

The model of an incubatory presented by me is simply made after the one I explored. There are others in Egypt twice as large as this one, and many smaller. The proprietor of an incubatory at Maydoom told me the hatch of his in one season reached 500,000 chicks. To build one in this country is not attended with great expense. The one I have described cost less than $1,000. The expense of construction in America would be far greater; but, at any cost, I would not advise any of my countrymen to engage at home in such an expense without first sending to this land of ancient memories and strangest costumes for an Egyptian who knows how to construct an incubatory and for attendants who understand thoroughly the mysteries of the ovens and the treatment of eggs and chicks.

JOHN CARDWELL, Consul General.

ON SULPHITES, THEIR STABILITY AND PRESERVATION.*

By JOSEPH C. BELCHER.

WHEN we burn a piece of sulphur in air or oxygen, there is formed a suffocating gas of a sharp, penetrating odor; freely soluble when brought in contact with water, producing what is known to chemists as a solution of sulphur*ous* acid, according to the following equation:

$$\underbrace{S}_{\text{Sulphur}} + \underbrace{O_2}_{\text{Oxygen}} + \underbrace{H_2O}_{\text{Water}} = \underbrace{H_2SO_3}_{\text{Sulphurous Acid}}$$

Now, although sulphurous acid (H_2SO_3) is the principal body formed, yet some is carried a stage further in oxidation, resulting in the production of traces of sulphur*ic* acid (H_2SO_4), which always accompany sulphurous acid prepared by burning sulphur in air or oxygen, and dissolving the resultant products in water. This aqueous solution of sulphurous acid is very unstable and, when exposed to free access of air, is gradually converted into the more stable and permanent body, sulphuric acid, or what is commonly known as oil of vitriol.

The facility with which sulphurous acid combines with an additional atom of oxygen is a property also true to a greater or less extent of its salts (sulphites). [Here sulphur was burned in a bottle containing air, and the gaseous product shaken with water.] The presence of sulphur*ic* acid was clearly demonstrated by the following experiments:

1. With a little of the water from the bottle in which the sulphur had been burned, the formula "H_2SO_4" was written on a piece of blotting paper, and warmed over a spirit lamp, when the presence of sulphuric acid was rendered evident by the formula being charred upon the paper.

2. It was shown that a precipitate of sulphite of barium was soluble in a solution acidified with hydrochloric acid, but sulph*ate* of barium was not. The presence of sulphuric acid in the liquid, from the bottle in which the sulphur had been burned, was then demonstrated by acidifying a portion of the latter with hydrochloric acid, and adding barium chloride, when a precipitate of barium sulphate was produced.

When sulphur dioxide (SO_2) is brought in contact with nascent hydrogen, this latter body is oxidized with formation of water, by combining with the oxygen of the first mentioned body, while the sulphur combines with hydrogen, forming sulphureted hydrogen thus:

$$\underbrace{SO_2}_{\text{Sulphur Dioxide}} + \underbrace{3H_2}_{\text{Hydrogen}} = \underbrace{H_2S}_{\text{Sulphureted Hydrogen}} + \underbrace{2H_2O}_{\text{Water}}$$

This is an instance of a reducing agent becoming an oxidizing one. All bodies capable of evolving SO_2 under the circumstances stated (hyposulphites, etc.) give this reaction, but we are at present only considering sulph*ites* which are detected by this reaction, even if present in very minute quantities; for if we allow the sulphureted hydrogen produced to impinge on a piece of filter paper soaked in lead acetate, it is immediately turned brownish-black or black, from the formation of lead sulphide. Sulph*ates* do *not* give this reaction. [Here the experiment was shown by adding a little sodium sulph*ite* to a test tube in which hydrogen was evolved from pure zinc and hydrochloric acid.] A solution of iodine is decolorized by sulphur dioxide, a reaction which also enables us to detect minute quantities of the latter.

Sulphurous acid is a bi-basic acid, *i. e.*, it contains two atoms of replaceable hydrogen; when one atom is displaced by a monad element we have a *hy*drogen or acid salt produced; when two atoms are displaced we have a normal, or what is commonly called neutral salt. Of those salts of sulphurous acid which are soluble in water, we have the acid sulphites of barium, strontium, calcium, and magnesium, and the neutral and acid sulphites of lithium, sodium, potassium, and ammonium. Most other sulphites are insoluble.

The sulphites of sodium and potassium are mostly used by photographers, especially the former, of which there are four in number: (1) normal or neutral sulphite, Na_2SO_3+7Aq; (2) the acid or bisulphite, $NaHSO_3$; (3) meta-sulphite, $Na_2S_2O_5$, or $Na_2SO_3.SO_2$; (4) sesqui-sulphite, $Na_2SO_32NaHSO_3+nAq$; this latter discovered by Mr. J. B. Giles, F.I.C.

The neutral sulphite of sodium of commerce is prepared by saturating the carbonate in solution with sulphurous acid, and adding to it while warm as much sodium carbonate as it originally contained; conse-

* Lecture delivered before the London and Provincial Photographic Association.—*Reported in Photo. News.*

quently, through carelessness in manufacture, many samples show a large excess of the latter, and although the sulphite crystallizes better from a solution containing a small quantity of sodium carbonate, still, in a carefully manufactured sample, this should never exceed 1 or 2 per cent. A pure salt of this description is manufactured by Messrs. A. Boake, Roberts & Company, of Stratford, E.; also a "special photographic salt" and alkaline meta-sulphites. I am requested to mention that these sulphites are patent articles, and can only be obtained from or through this firm. By their kindness I am able to show you these fine specimens of sulphite and meta-sulphite. [Here the specimens were exhibited, the lecturer dilating upon their great purity, and recommending them as standard articles in preference to making allowances in the commercially impure samples.]

The presence of an excess of sodium carbonate in the sulphite causes great annoyance to photographers, as, by its varying amount, they are unable to make any allowance in their formula, which demands an addition of a definite amount of the former in conjunction with the latter for developing. The presence of carbonate in sulphite of sodium is easily detected. The method depends upon the fact that carbonic acid gives a beautiful red color with an alcoholic solution of phenolphthalein while sulphurous acid produces no action in this respect. [Here the experiment was shown.]

If, then, we dissolve some of the sulphite above referred to containing only 1 or 2 per cent. of carbonate, add a little alcoholic phenolphthalein, we have a red color developed due to the carbonic acid, and, on adding carefully a solution of the meta-sulphite—preferably potassium meta-sulphite, as this crystallizes much more freely than the sodium salt, and is more stable—till the color just disappears, the result is a pure solution of neutral or normal sodium (potassium) sulphite, the SO_3 radical combining with the sodium which was previously combined with the CO_3 radical. The question, therefore, of obtaining a pure solution of normal or neutral sulphite of sodium need no longer perplex photographers.

I pointed out in the first part of my lecture that sulphurous acid gradually became oxidized to sulphuric acid, and that sulphites oxidized more or less rapidly to sulphates, which latter, of course, affects the purity of the salts when stored; and I suggest, as a means of preservation, that a pure sample, such as that referred to, and manufactured by Messrs. A. Boake, Roberts & Co., should be kept in well-stoppered bottles, with the crystals covered with pure ether, which procedure I am of opinion, would prevent oxidation; the ether being very volatile, when the crystals were wanted they could be removed from the bottle and placed upon blotting paper till they became dry preparatory to dissolving. [Here crystals were shown in support of this, which had been kept under ether for six months.]

To summarize: I have pointed out (1) that the sulphites oxidize more or less rapidly, forming sulphates, and (2) have suggested a means of preserving by keeping the crystals below the surface of ether; (3) I have mentioned and demonstrated simple tests within the capability of any photographer to perform for recognizing the presence of sulphates and sulphites, and the detection of carbonate in the latter; and, lastly, by the use of the meta-sulphite how to obtain a pure solution of the neutral or normal sulphite.

In conclusion, I desire to acknowledge my thanks to Professor Lewes, Royal Naval College, for the loan of his apparatus, which has enabled me to illustrate these experiments, and to sincerely thank my friend, Mr. Haddon, for suggesting the subject of this lecture, which has given me such pleasure to deliver to you this evening, and your very kind attention and manner in which you have received me. I particularly wish to acknowledge my indebtedness and thanks to Mr. J. B. Giles, F.I.C., for much information given me concerning the sulphites manufactured by Messrs A. Boake, Roberts & Co., whom I have also to thank for their courtesy and kindness in supplying the two specimens of sulphites.

[NATURE.]

LIQUID CHLORINE.

By A. E. TUTTON.

ALTHOUGH chlorine was shown by Faraday so long ago as the year 1823 to be one of the more easily condensable gases, yet, no doubt owing in a large measure to its very disagreeable nature, comparatively little has hitherto been known concerning its properties when in a liquefied state. In view of the fact that chlorine is now stored in the liquid state for the use of manufacturing chemists in a similar manner to carbon dioxide, sulphur dioxide, and ammonia, it is imperative that something more definite should be known as to the relations of liquefied chlorine to temperature and pressure. Consequently, a very complete investigation of the subject has been made by Dr. Knietsch at the request of the directors of the "Badischen Anilin-und Sodafabrik," of Ludwigshafen, and his results, of which the following is a brief account, are published in an interesting communication to the current number of *Liebig's Annalen* (Band 259, Heft 1, p. 100).

The work includes the determination of the vapor tension of liquid chlorine at temperatures from —88° C. to 146° C. (its critical point), a complete examination of its behavior near the critical point, and the determination of its specific gravity and coefficient of expansion for a range of temperature between —80° and + 80°.

Liquid chlorine generally appears to possess a yellow color. When, however, the color of a long column is examined, it is found to have a distinctly orange tint. The absorption spectrum does not exhibit any characteristic bands, but the blue and violet portions of the spectrum are completely absorbed, the transmitted spectrum thus consisting of the red, orange, yellow, and green.

VAPOR TENSION OF LIQUID CHLORINE BELOW ITS BOILING POINT.

The apparatus used for this determination consisted of a kind of distilling flask, whose side tube was connected by means of a piece of strong-walled caoutchouc tubing with a wide manometer tube. The flask was about half filled with liquid chlorine, and was immersed in a bath also containing liquid chlorine whose temperature could at the same time be kept equal throughout, and be very finely regulated by means of a current of air driven in through a tube passing to near the bottom of the bath.

In commencing a series of determinations the chlorine in the flask was first made to boil, thereby driving out the air remaining in the apparatus. The neck was then closed by means of a caoutchouc stopper well coated with glycerine, and the open end of the manometer was allowed to dip into a vessel containing concentrated sulphuric acid. As the flask became cooled by immersing it in the cold chlorine in the bath, sulphuric acid was drawn into the manometer until it attained a height of 3-5 cm., when the caoutchouc connection was momentarily pinched while the open end of the manometer was transferred to the mercury trough. The small column of sulphuric acid thus standing above the mercury column effectually protected it from the corroding action of the chlorine. The bath was then cooled gradually, and a series of readings taken of the temperature of the bath, by means of an alcohol thermometer, and of the position of the meniscus of the mercury in the manometer. The small column of sulphuric acid was of course calculated to its equivalent height of mercury, and added to the measured height of the mercurial column. By careful use of the current of dry air the liquid chlorine of the bath was found capable of being reduced in temperature as low as —60° C. The lower temperatures, down to —88°, were attained by mixing more or less solid carbon dioxide with the chlorine. The results obtained are given in the table at the end.

DETERMINATION OF THE PRESSURE OF LIQUID CHLORINE FROM ITS BOILING POINT TO 40° C.

The data at present existing upon this subject are very meager and conflicting. Davy and Faraday found the pressure at 15° C. to be 4 atmospheres, while Niemann gives the pressure at 0° C. as 6 atmospheres, and at 12·5° C. as 8 atmospheres. As this is a most important point in regard to the storage of liquid chlorine in metallic bottles, great pains have been taken to arrive at unimpeachable results, and as the most certain method of measuring the pressure a high column of quicksilver was employed. The apparatus consisted of a U-tube, one limb of which was narrower than the other, and prolonged upward to a height of over 8 meters. The other and wider limb was joined at the top by means of a capillary tube to a cup, serving the purpose of a funnel for introducing the liquid chlorine. In commencing an experiment, a convenient quantity of mercury was first poured in, so as to stand in the wider limb at about a quarter its height. A column of sulphuric acid was then introduced into the wider limb, so as to protect the mercury, and finally the liquid chlorine was introduced through the funnel by a process of alternately warming and cooling. The cooling was effected by pouring a little liquid chlorine over a piece of cotton wrapped round the limb and evaporating it by a strong current of air. When the limb was quite full the chlorine occupying the capillary tube was evaporated by the warmth of a small blowpipe flame, and the capillary fused up. The apparatus was then immersed, until the wider limb was covered, in a bath of liquid sulphur dioxide for temperatures up to 0°, in ice for the determination at 0°, and in water agitated by a current of air and either cooled by ice or warmed by a small flame for temperatures up to 40°. For the comparatively higher of these temperatures it was of course necessary to pour mercury into the longer limb so as to prevent the mercury in the wider limb being driven round the bend. Complete results are given at the end, but it may be remarked in passing that the pressure at 0° is 3·66 atmospheres, and at 15°, 5·75 atmospheres.

DETERMINATION OF THE PRESSURE AT HIGHER TEMPERATURES.

For these yet more dangerous and difficult experiments a metal apparatus was employed, similar in principle to that just described, except that the pressures were measured by a metal gauge manometer, which had previously been completely tested and its readings verified. It was found important in these experiments not to employ too much chlorine, as owing to the immense coefficient of expansion the whole space might become full of liquid, and further heating would cause the generation of dangerously high pressures. For temperatures up to 100° a water bath was employed, and for the higher temperatures up to the critical point 146° an oil bath, both kept in circulation by a rapid current of air. The pressure at the critical temperature of 146° C. was found to be as high as 93·5 atmospheres.

CRITICAL POINT OF LIQUID CHLORINE.

The critical point was determined in a separate experiment and some very interesting results were obtained, the yellowish green color of chlorine perhaps assisting in rendering the appearance of what has sometimes been termed the fourth state of matter between the liquid and the gaseous more distinct than usual. A hard glass tube of 8 mm. diameter was about one-third filled with redistilled dry liquid chlorine and sealed. A small thermometer, whose readings commenced at 140°, was attached to it by platinum wire, and the whole very slowly heated in a bath of vaseline. The observations were made with the naked eye, the observer being protected from any possible explosion by a thick glass plate. At 140° extremely small bubbles began to be developed throughout the mass of liquid. At 144° the hitherto sharp meniscus began to disappear, and at 145° the presence of a liquid was only evident by the more intense yellow color and higher refractive power of the lower portion of the tube. At 146° the contents of the tube were homogeneous throughout, the critical point being attained, and the liquid converted into gas. On allowing the tube to cool slowly, the condensation always commenced below 146°, with the formation of a cloud and a fine rain of minute yellow spheres of liquid chlorine. The rain was generally apparent throughout the whole of the upper portion of the tube. Sometimes, however, the liquid meniscus again appeared without any previous manifestation of precipitation.

SPECIFIC GRAVITY AND EXPANSION OF LIQUID CHLORINE.

It is a curious fact that many gases when compressed to the state of liquid expand enormously when heated as compared with ordinary liquids, the amount of expansion sometimes exceeding that of the gas itself. Liquid chlorine is no exception to this rule, and it was absolutely essential that its rate of expansion should be thoroughly investigated, in order that storage bottles should not be filled to a dangerous extent. For temperatures up to 36° C. a closed dilatometer of glass was employed, the long cylindrical bulb of 60 c. c. capacity and part of the stem being filled with liquid chlorine, and the remainder of the stem with chlorine gas. The whole apparatus was immersed in a long cylindrical bath. For the lowest temperature, of —80°, the bath was filled with solid carbon dioxide. For the determination of the specific gravity at the boiling point of chlorine, a bath of boiling liquid chlorine itself was employed, no less than 3 kilogrammes being required. Between the boiling point and 0° the substance used in the bath was liquid sulphur dioxide. For the determination at zero powdered ice was employed, and for the higher temperatures a water bath kept in motion by an air current. It was not possible to proceed higher than 36° with this apparatus, on account of the danger of explosion. The higher determinations were made by means of a hydrometer suspended in liquid chlorine inclosed in a tube of hard glass which was immersed in a glass water bath heated to the required temperature.

It will be seen from the following table that liquid chlorine is indeed a very expansible substance. The coefficient of expansion at 80° is already 0·00346, nearly equal to that of gaseous chlorine, and is rapidly increasing, so that before the critical temperature of 146° is attained, the coefficient of expansion will be considerably higher than that of the gas.

Following is a table showing the pressure, specific gravity, and coefficient of expansion of liquid chlorine for every 5° of temperature from —80° C., calculated from the formulæ derived from the experimental data obtained.

Temperature.	Pressure.	Specific gravity.	Mean coefficient of expansion.
—102° C.	Solid (Olzewski).	——	
— 88	37·5 mm. Hg.	——	
— 85	45 0 "		
— 80	62 5 "	1·6602	
— 75	88 0 "	1·6490	
— 70	118 "	1·6382	
— 65	159 "	1·6273	
— 60	210 "	1·6167	
— 55	275 "	1·6055	0·001409
— 50	350 "	1·5945	
— 45	445 "	1·5830	
— 40	560 "	1·5720	
— 35	705 "	1·5589	
— 33·6	760 "	1·5575	
— 30	1·20 atmospheres.	1 5485	
— 25	1·50 "	1·5358	
— 20	1·84 "	1·5230	
— 15	2·23 "	1·5100	0 001793
— 10	2·63 "	1·4965	
— 5	3·14 "	1·4830	
0	3 66 "	1·4690	
+ 5	4·25 "	1·4548	0·001978
+ 10	4·95 "	1·4405	
+ 15	5 75 "	1·4273	0·002030
+ 20	6·62 "	1·4118	
+ 25	7·63 "	1·3984	0·002190
+ 30	8 75 "	1·3815	
+ 35	9·95 "	1·3683	0 002 60
+ 40	11·30 "	1·3510	
+ 50	14·70 "	1·3170	0 002690
+ 60	18·60 "	1·2830	
+ 70	23·00 "	1·2430	0·003460
+ 80	28·40 "	1·2000	
+ 90	34 50 "		
+100	41·70 "		
+110	50·80 "		
+120	60·40 "		
+130	71·60 "		
+146	93·50 "	Critical	point.

An interesting result, which is not noticed by Dr. Knietsch in his paper, is obtained on calculating the specific volume of chlorine from the determination of specific gravity at the boiling point, —33·6°. On dividing the atomic weight 35·5 by 1 5575 the specific gravity at the boiling point, the number 22 8 is obtained for the atomic or specific volume of chlorine, a number practically identical with that derived by calculation from the numerous determinations of the specific volume of compounds containing chlorine.

In this respect chlorine resembles bromine and the compound radicals NO_2 and CN, which were shown by Prof. Thorpe (*Journ. Chem. Soc.*, 1880, 382) to occupy the same volume in the free state as in combination.

A. E. TUTTON.

A METHOD OF DETECTING CHEMICAL UNION OF METALS.

By DR. G. GORE, F.R.S.

IT is well known that evolution of heat during the mixing of two substances is a sign of chemical union, that considerable heat is evolved during the melting together of certain metals, for instance, zinc and platinum, and M. J. Regnauld has shown that while zinc during its amalgamation by mercury absorbs heat and becomes more electro positive, cadmium by amalgamation evolves heat and becomes less electropositive (*Comptes Rendus Acad. Sci.*, June 10, 1878; *Chemical News*, vol. xxxviii., p. 33).

Having already found in a large number of instances that the chemical union of two soluble substances, such as halogens, acids, salts, etc., might be detected by the depression of voltaic energy which occurs when the two dissolved substances are in the proportions of their ordinary chemical equivalents (see *Proc. Roy. Soc.*, vol. xlv., p. 265; *Examples of solution compounds*, *Proc. Birm. Phil. Soc.*, vol. vii., p. 33; *Chemical News*, 1890, vol lxi., p. 172), I have adopted a similar method in this case, and have made a series of experiments to ascertain the relative amounts of voltaic energy in a one per cent. aqueous solution of common salt, of a

series of amalgams composed of different proportions of cadmium and mercury, and observed whether there was a distinct depression of that energy indicating chemical union, when the particular amalgam composed of equivalent weights of the two metals was employed.

As I had previously found that the amalgam changed in electromotive force spontaneously, in order to balance this influence I employed, instead of a voltaic couple composed of platinum and one bar of a series of bars of different composition, a couple composed of a bar of fixed composition formed of the two metals in the proportions of their equivalent weights, and one bar of a series of bars of different composition. The two bars in each experiment were connected with an ordinary torsion galvanometer of 50 ohms resistance, and the amount of permanent deflexion of the needles after about half a minute was recorded. This method was found sufficiently sensitive for the purpose. The composition of the bars of varied composition is shown below by the chemical formulæ.

After some preliminary experiments, the results of which agreed with those given, the following series was made:

Voltaic couple.			Deflexion.
CdHg	with	Cd	+5
"	"	$Cd_{17}Hg_{10}$	3·3
"	"	$Cd_{15}Hg_{10}$	3
"	"	$Cd_{13}Hg_{10}$	1
"	"	$Cd_{11}Hg_{10}$	1
"	"	$Cd_{10}Hg_{10}$	0
"	"	$Cd_{10}Hg_{11}$	+4
"	"	$Cd_{10}Hg_{13}$	−2
"	"	$Cd_{10}Hg_{15}$	−9
"	"	$Cd_{10}Hg_{17}$	−4
"	"	Hg	−5 to 6

As the amounts of deflection varied with different parts of the surface of the same bar, the surfaces of the bars were scraped quite clean and the experiments with the amalgams $Cd_{11}Hg_{10}$, $Cd_{10}Hg_{10}$, and $Cd_{10}Hg_{11}$ repeated. The same numbers as given above are obtained.

The numbers obtained in each case show a distinct depression of strength of current with the amalgam composed of equivalent weights of the two metals, similar to that obtained with halogens, acids, and salts, and indicate that the two metals chemically unite together in the proportions of their ordinary chemical equivalents. The method may therefore probably be employed for the purpose of detecting the chemical union of metals.

NEW SCHOOL OF MEDICINE OF PARIS.

Now that the work on the new School of Medicine is nearly finished, and that the professors and students are going, at the reopening, to take possession of the new apartments, our readers will feel indebted to us for giving them as complete a physiognomy of the whole as possible.

Let us take up first the buildings of the new school, properly so called. Our bird's-eye view drawing represents the buildings, the annex of the Faculty of Medicine, and separated from the latter by Ecole-de-Medecine Street. Our drawing is very accurate and gives a very good idea of the establishment. We shall point out a few curious corners of it to the reader.

GUARDIAN OF THE ORFILA MUSEUM.

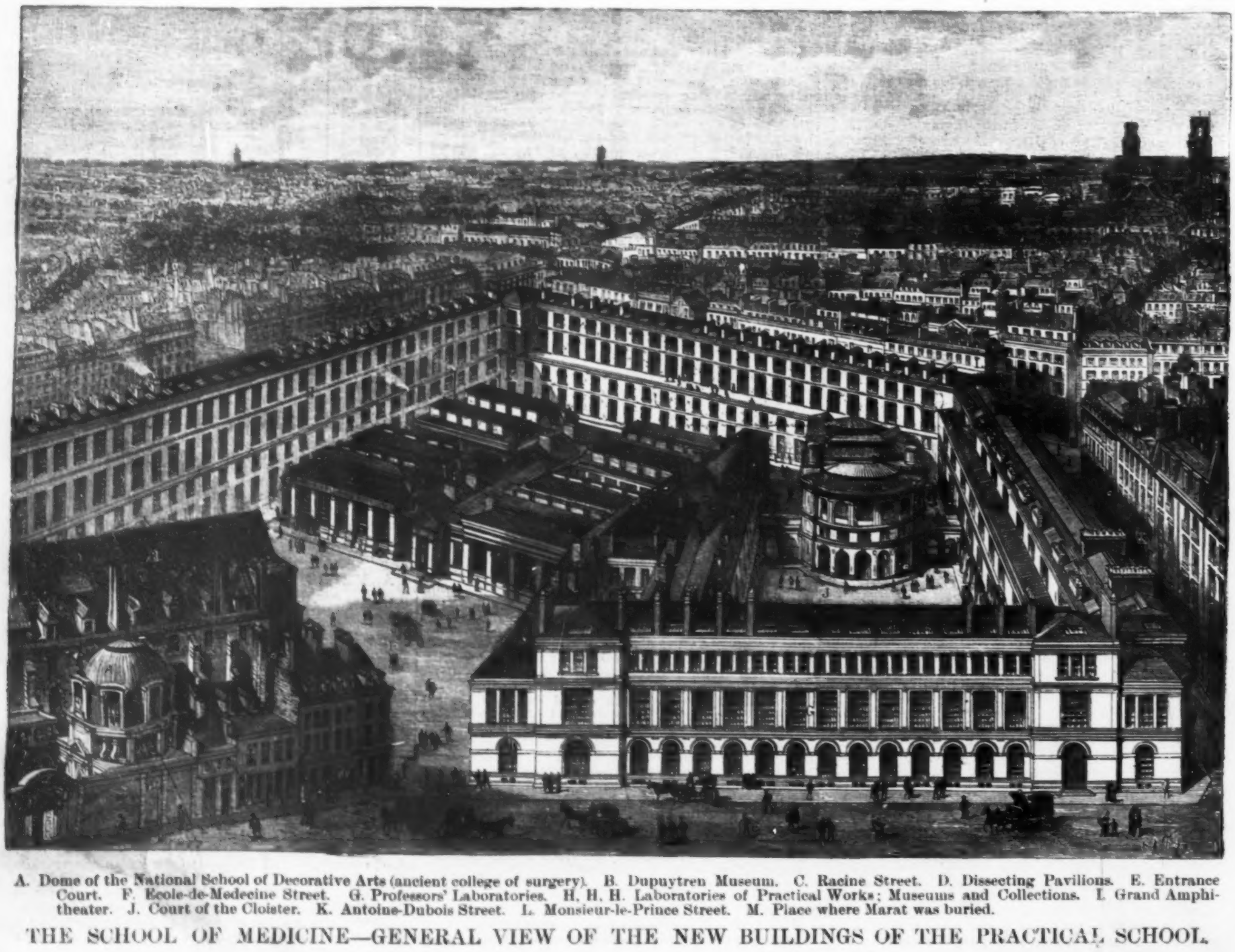
Let us say, in the first place, that it is very nearly finished, as far as the masonry work is concerned. The first stone was laid on the 4th of December, 1888, by Mr. Bardoux, who was then minister of public instruction. It occupies a total area of 13,000 square meters, and cost 5,500,000 francs. The plans are due to the eminent city architect, Mr. Ginain, and the work has been carried out by Mr. Dupre, the congenial and learned inspector, to whom we are indebted for the historic data that follow.

Monsieur-le-Prince Street and the wing that skirts it are constructed directly over the trench situated outside the walls of Paris under Philip Augustus. The courtyard of the cloister and the parts that surround it are the remains of the ancient and celebrated convent of the Cordeliers, which was placed back to back with the church burned under Henry III., and was entirely demolished in 1793. The stones of the gallery behind the professors' laboratories are also of the epoch; they have simply been redressed.

PROFESSOR OF THE FACULTY OF MEDICINE.

At the extreme left-hand corner of the drawing is the ancient church of Saint Cosmus, of the barber surgeons. The dome seen at the side belongs to the National School of Decorative Arts. Finally, at the extreme part, in the court, at the intersection of Racine and Monsieur-le-Prince Streets, is the place where Marat was buried.

Half of the buildings is already occupied, including the halls of natural history, physics, and medical chemistry, and the dissecting pavilion. This is the part, then, that we are going to visit in company with our draughtsman, after having traversed the build-



A. Dome of the National School of Decorative Arts (ancient college of surgery). B. Dupuytren Museum. C. Racine Street. D. Dissecting Pavilions. E. Entrance Court. F. Ecole-de-Medecine Street. G. Professors' Laboratories. H, H, H. Laboratories of Practical Works; Museums and Collections. I. Grand Amphitheater. J. Court of the Cloister. K. Antoine-Dubois Street. L. Monsieur-le-Prince Street. M. Place where Marat was buried.

THE SCHOOL OF MEDICINE—GENERAL VIEW OF THE NEW BUILDINGS OF THE PRACTICAL SCHOOL.

ings of the old school, preserved, and arranged in an entirely new way.

The buildings of the old school comprise the facade upon the Boulevard Saint Germain and the two side wings on Hautefeuille and Ecole-de-Medecine Streets. We find here the examination halls, the two amphitheaters, the offices of the secretary, the library, the council hall, and the Orfila Museum.

It is through the museum, which leads to the examination halls, that we shall begin our visit. *A tout seigneur, tout honneur:* Here, in the first place, we have the guardian of within. His cap planted squarely upon his ears, his face full and placid, clad in a coat ornamented with large, shining metallic buttons, this important person, half seated upon a table in the lighted bay of a high window, reads his journal with all the importance that becomes him. Over his head an immense transparent clock allows the hours to slip by with a discreet noise of carefully oiled wheelwork. At his sides there are glass cases containing the skeleton of every known species of monkey, and the casts of whose faces form a chain of which the honest, chubby face of the guardian seems to be the last link.

OFFICE OF THE CHEF OF ANATOMICAL WORK.

Let us continue our way through the galleries of the museum. We meet a professor of the faculty, who is walking along slowly, absorbed in the reading of his notes, and doubtless dreaming of some universal, and especially infallible, remedy.

Behind him, a carcass in a glass case assumes graceful poses; while standing on their feet, like horrid phantoms, with fleshless heads resembling the bills of monstrous birds, skeletons of quadrupeds gaze from their empty orbits at the furred toga and the solemn *mortier*, and smile with their yellowing jaws. It is a long time ago that they found the remedy for all evils, these creatures!

IN THE DISSECTING HALL.

We now reach the examination halls. The candidate is quite generally disposed to find the room (whatever it be) imposing in which his future is to be decided. This impression must be still further increased by the severe aspect of the vast rooms of the school, with arched ceilings traversed by large girders of oak. Upon the light walls the portraits of illustrious savants somewhat darkened by time seem to fix the postulant with a scrutinizing eye. Do they judge him insufficiently prepared, or *dignus intrare?* Mystery! Their mouth will never more render those so impatiently awaited for decrees, their hand will never more drop either black or white balls into the urn; and perhaps they have in their own turn passed an examination before a judge terrible in another way.

A COURSE IN THE GRAND AMPHITHEATER.

One of our large engravings makes us spectators at a course in obstetrics. The professor, seated, holds in his hand a specimen of an imperfect embryo made of rubber, which he uses for the needs of his demonstrations. It is a strange image this, with its pyriform cranium, its congested limbs, its inflated abdomen turned and returned in all directions, half dancing puppet and half gnome, now gesticulating awkwardly, held aloft and turned about by the professor so as to be seen from all points of the hall, now resting and left aside momentarily at the corner of the table in attitudes of ridiculous *abandon*. The female students, particularly interested, look fondly upon it, as if it were some large scientific doll. Every age has its pleasures and its playthings.

The professor, with his neck encircled by a collar of which one of the points falls limp over a high black cravat, and his broad round back, suggesting the sedentary man, speaks in a loud voice, in a conversational style, intermingling theories with demonstrations.

His robust and skillful fingers maneuver the puppet

ARRIVAL OF SUBJECTS.

through the sure and continuous touches of the prestidigitator. In front of him upon a table covered with black cloth are placed the inkstand, the traditional glass of water, the notes, and a long pointer designed to show the auditors the various parts of explanatory drawings fixed by means of pins upon a large blackboard.

Beyond the iron balustrade that separates him from his audience, rise by stages the fifteen tiers of seats of the immense elliptical hall, which easily seats the five or six hundred pupils—assiduous auditors of the course. Entrance is had through the upper part of the hall. So, as soon as the doors are opened, it is a true human cascade that tumbles over the benches in order to get below as near as possible to the professor. In this steeple chase of a new kind, the female students, despite the disadvantage of being encumber-

A COURSE IN THE GRAND AMPHITHEATER.

ed with petticoats, rarely allow themselves to be distanced. They are generally grouped upon the first row of benches, the only ones seen in our engraving. We would fain believe that, faithful to the ancient traditions of French gallantry, their fellow disciples of the strong sex give up the best places to them. But such a hypothesis seems scarcely probable after an examination of the very similar sketches of those young ladies whom our draughtsman has placed in the front line. Although the study of medicine develops spirit and courage, it does not appear to exert any beneficent action from the standpoint of plastic beauty—a perishable attraction, however, and an unimportant one, at least that is what homely people say.

Decidedly, gallantry has no place in this affair. So in the students of our engraving we observe none of those vexatious yet very natural abstractions that might result from the accidental or habitual vicinage of young and pretty women. Ill kempt and badly shaven, they take their notes assiduously, regardless of the presence of their companions, who are no more elegant and no more bespectacled than they themselves are. Fathers lead their sons hither without danger.

But the doorkeeper—ah, the doorkeeper! Standing in a pose full of both distinction and ease, he seems in this place the last refuge of elegance. His silver chain sparkles upon the black cloth of the coat that sets off his figure. Above a vast expanse of shirt bosom of a vapory white appears his head, covered with hair of more showy whiteness still, and divided into harmonious curls.

He listens with vague look, with condescending interest, just like a gentleman of leisure who would have dropped in on passing by.

Let us now visit the school properly so called. We

THE GARDEN.

enter through a door over which this inscription is carved in stone:

FACULTE DE MEDECINE. ECOLE PRATIQUE.

Inclosed by the buildings, there are three gardens with fountains, which give the eye relief from the severe aspect of the masses of dressed stone. Under the arcades of the basement, we observe fifteen niches occupied by dogs of every stripe and size, but of uniformly surly manners. At the bars of their cages, the injunction of the Roman mosaics, *Cave Canem*, is reproduced, reviewed and corrected in this very modern form:

Rabies. It is forbidden to touch!

Forbidden to touch mad dogs! Are there people, then, who are dying with a desire to do so?

At a few steps from these dangerous neighbors, a workman, pipe in mouth, is following the precept of Candide: He is cultivating his garden, under the benevolent eye of the skeletons and of the skinned animals reclining in the glass cases of the galleries, and without any other care, between death and rabies, than his daily duty, he whistles a café concert air that is uninterrupted by the growlings of the dogs.

Let us leave this unconscious philosopher and enter the long gallery separated into pavilions wherein anatomical work is performed.

CABINET OF THE CHEF OF ANATOMICAL WORK.

This *retiro* of the chef is situated in the central pavilion. The master is seated in front of a table covered with papers and books. He is directing the operations of several of his best pupils, who are occupied in reproducing upon huge sheets of paper, and in enlarging in colossal proportions, the bones and muscles of the foot, hand, leg, etc. One of these sheets, simulating a trophy of bones, is placed back of the professor.

These drawings, done in pastel and charcoal crayon, are to be placed in the amphitheater during lecture courses, so as to be seen from all the tiers of benches. In the foreground stands a skeleton specially charged with the role of cloak bearer. Wrapped in the pelisse of the savant, his high hat slightly inclined upon the place where the ear was, the dead personage has the appearance of being disguised, in order to attempt an escape from the tomb and to enter into life again with a pretty frolicsome disposition.

Each dissecting pavilion is placed under the surveillance of a professor called the chief prosector, who is assisted by aids in anatomy. He has an office to which is added a dressing and wash room, and directs the work of the pupils in the dissecting hall. Each of these halls is provided with twenty black marble tables, upon which the subjects are placed, with a black board for the lessons, and with a complete assortment of skeletons. Here the pupils of both sexes go and come, sing and joke, and cut and carve. Here we have a female student busy in the exercise of her functions; she wields the scalpel with great ease and devotes herself to a cadaver whose image we shall not induce you to examine too attentively. And she is pretty withal, the unfortunate!

ARRIVAL OF SUBJECTS.

At certain hours every day, wagons enter the court from all the hospitals of Paris. They are painted black and are carefully closed. No guard escorts them, and no one has ever heard speak of an attempted escape by any of the numerous passengers that they carry to a horrid destination.

Hall boys in blouses and long aprons await the arrival of the wagons in the court, under the surveillance of a functionary of grave exterior—the chef of materiel. Two of them approach and open the doors. In the interior of the mysterious car, strange packages lie extended in a line upon boards forming drawers. The canvas bags that envelop them exhibit human forms under their rigid folds. These are the bodies of poor devils that have died in the hospital and that the Public Assistance sends to the Faculty of Medicine to be dissected—in technical terms, they are *subjects*. Just as the bodies of soldiers found after a battle carry their tag of identity, just so each of the *subjects*, conquered in the eternal battle of life, has a label sewed to his bag, showing his name and that of the hospital where he fell.

While the boys carry the subject away, the chef adjusts his glasses and gravely takes note of the inscription on the label.

THE CRYPT.

The boys carry the subject down into the crypt,

THE CRYPT.

which consists of vast halls in the basement. Our engraving gives the terrible and imposing aspect of these vaulted caves, with thick and black walls. It is here that the subject is to rest for some hours still, stretched out naked. Its lividity, shown by the reflection of an electric lamp, is set off by a bed of granite at the side of some poor companion in supreme misery, awaiting the scalpel that is to disperse its poor limbs forever. After the operation, the debris, thrown into bags, will be carried to Père la Chaise and consumed in the crematory apparatus. Finally, the ashes will rest in peace, for they can be used for nothing.—*L'Illustration.*

CONSTIPATION: ITS NATURE AND TREATMENT.

By C. L. DODGE, M.D., Kingston, N. Y.

SOME writers make a distinction between constipation and costiveness. This is unnecessary refinement, and serves no good purpose. We understand by either term insufficiency of evacuations from the bowels.

The affection is apt to become chronic; it is then termed habitual constipation. Reference is had in this article to this form of the disorder. Occasional constipation requires only a brief notice.

Constipation as a functional disorder is extremely frequent. "It is probably one of the most common of the slight derangements to which civilized man is subject. Whether savages suffer from it, I do not know, but unquestionably the majority of persons forming a civilized community experience the discomfort" (Beale).*

Various causes give rise to this affection. "Deficiency of bile and the intestinal secretions may enter into the causation in some cases, but probably the importance of this cause of constipation has been overestimated. Constipation is not always present when no bile enters the alimentary canal in certain cases of jaundice" (Flint).† Sedentary habits are also stated to be a frequent cause. Inattention to the calls of nature is an important factor in the cause of this affection, as it begets a tolerance on the part of the lower bowel, so that a large accumulation of excrementitious material may take place without giving any annoyance to the patient. This accumulation gives rise to overdistention and paralysis of the muscular coat of the intestine, and in this way a chronic condition is established.

* "Slight Ailments," p. 111.

† "Practice of Medicine," p. 470.

Constipation is said to be a cause of piles. I think the converse equally true; defecation being painful, it is deferred as long as possible, and one condition reacts on the other. As Van Buren says,* "The individual who sits straining to get rid of the contents of his large bowel is not aware of the damage he is doing to the parts which he is subjecting to violence, and how surely he is courting prolapsus or piles, if not abscess or fistula. In disregarding the calls of nature few persons recognize the danger they incur of loss of expulsive power from over-distention and consequent costiveness from atony, of inflammation, stricture and abscess.

"Let us glance for a moment at what anatomy teaches us of this. The muscular coat of the rectum consists of a layer of internal fibers which circle around the gut, and a layer of external fibers which run in the direction of its length. The circular fibers grow larger and more powerful as they approach the lower end of the bowel, and just above the external sphincter muscle they are collected into a mass of some volume, to which the name of *internal sphincter* is given.

"A large proportion of the external longitudinal fibers, when they reach this ring, double around its lower border, passing upward and inward to seek an insertion into the fibrous substratum of the mucous membrane of the gut, where they are firmly implanted. From this arrangement it results that, when, in the act of defecation, these longitudinal fibers contract, they tend first to draw down and then to evert the mucous membrane of the lower end of the rectum; just what we see happen in the horse. When the evacuation of the contents of the bowel takes place naturally this protrusion is promptly retracted by the action of the *levatores* and the natural contractility of the parts; but when the evacuation is difficult or impossible, and the effort is prolonged or frequently repeated, the protruded mucous membrane becomes congested and swollen, and is retracted with more difficulty. Perhaps a portion of it remains outside, and then the tumid and tender protrusion leads to the announcement on the part of the patient that he has 'an attack of piles.'"

Dr. Squibb† maintains that "insufficient supply of water or of succulent food is probably the ultimate cause of three-fourths of the cases of ordinary constipation." There also seems to be a predisposition to this affection on the part of some persons from childhood; indeed, we frequently meet with it in early infancy. The various causes enumerated are, doubtless, operative to a greater or less extent; but I believe that in a large number of cases, especially where the affection has existed from childhood, as is frequently the case, there is an inherent weakness of the muscular coat of the rectum.

The so-called therapeutic test is sometimes a valuable aid in diagnosis, as in obscure cases of syphilis or malarial poisoning. The therapeutic test will aid us in arriving at the true cause of many cases of constipation. Aloes in minute doses, as will be shown when the treatment is under consideration, suffices not only to relieve but to cure this affection in very many instances. The effect of aloes in small doses, as is well known, is to stimulate the lower bowel, especially the rectum. It excites intestinal secretion and increases peristalsis, and thus restores this portion of the intestinal tract to functional activity. This would seem to prove a previous condition of weakness, atony, or loss of function of the rectum. If this condition be relieved, the constipation in the majority of cases is cured.

Constipation is regarded by the laity as a slight ailment, and the average layman labors under the delusion that he is abundantly qualified to treat himself without the aid of a physician. In proof of this, witness the immense sale of nostrums designed to act on the bowels, and the vast fortunes amassed by pill manufacturers, from Brandreth down. Nine times out of ten the medicine is taken in purgative doses, which, causing a reaction, has to be repeated from time to time, until the individual is obliged to resort to a strong cathartic whenever a passage of the bowels is desired. Cases of this kind are the most difficult to treat, and they are very numerous.

The more unsatisfactory the treatment of a given disease, the more numerous will be the remedies therefor. The materia medica has been ransacked for remedies for constipation. To enumerate them all would require a small volume. I shall content myself by referring to the more important ones only.

Seidlitz powders, citrate of magnesium, and salts are household remedies. Pills‡ of all kinds, the composition of which is not known, are swallowed by the thousand, showing the extreme prevalence of this disorder. Mineral waters are largely used, and the sales thereof are increasing every year.

Dr. Squibb believes that plenty of plain water is all that is necessary to effect a cure. He says: § "The very common relief obtained in constipation from the use of the fashionable mineral waters is doubtless largely due to the water. As a large proportion of the effective mineral waters contain less than one-half of one per cent. of total solids, it is not difficult to understand that the water is an important, if not the most important, element; while it is very certain that water alone will answer an excellent purpose in the management of constipation."

Powerful purgatives are frequently resorted to; these give temporary relief, but are in no sense curative; the reaction which follows their use intensifies the existing condition. Some persons carry a piece of rhubarb root with them, and eat a little of this occasionally. "Of all agents to be selected for an habitual purgative, this is the worst. If once resorted to, its use is necessitated, in consequence of its secondary action, which is to cause constipation" (J. Milner Fothergill).‖ This is more especially the case when the root is carried in the pocket and a small portion eaten oc-

* Diseases of the Rectum," p. 400.

† "*Ephemeris of Materia Medica*, May, 1884.

‡ Crittenton's "Catalogue of Patent Medicines" contains over three hundred different kinds of cathartic pills, that is to say, over three hundred manufacturers are engaged in the laudable occupation of furnishing physic pure and simple to their suffering countrymen. Bitters, to the number of a hundred and fifty or more varieties, are also supplied, most of which are warranted to regulate the bowels, as well as to cure various other ailments.

§ *Ephemeris of Materia Medica*, May, 1884.

‖ "Handbook of Treatment," p. 419.

casionally; it soon becomes as necessary as the breakfast or dinner.

The compound licorice powder, the basis of which is senna, has now become a standard remedy for popular use. It is prompt, certain, and quite agreeable, and for children is an excellent combination.

Cascara sagrada is highly spoken of by some practitioners; the fluid extract is extremely bitter, but the elixir and the cordial of cascara are eligible preparations, and I have found them of service in a number of cases, especially with children.

The mineral waters vary greatly in their cathartic properties. Some, as Congress and Hathorn (Saratoga), are only slightly aperient, requiring several glasses to cause the bowels to act; others, like Friedrichshall and Hunyadi Janos, are strongly purgative, one glassful, or even less, taken in the morning, causing prompt and free catharsis. These waters are quite bitter, however, and to some persons objectionable on this account.

In addition to the above measures, local treatment is sometimes advisable; by this I mean the use of suppositories and injections. These aim at producing an immediate evacuation of the bowel, but are in no sense curative, as they do not tend to promote a more regular action in future, which is the chief end desired. Injections of cold water are resorted to by many persons for the relief of constipation, but it soon becomes necessary to repeat the operation every day, and, if persisted in for a long time, the muscular coat of the bowel becomes weakened, and the condition is actually made worse. This method of treatment is not to be recommended in chronic cases. Authority is not wanting in support of this opinion.

Suppositories are also used, especially glycerin suppositories. These are easily introduced into the rectum, and, if retained a few minutes, will cause a thorough evacuation of the lower bowel. In children I find it extremely difficult to prevent the expulsion of the suppository before sufficient glycerin has been dissolved to excite peristaltic action. Glycerin is quite irritating to persons suffering with piles, or where the rectum is hypersensitive from any cause. Before the introduction of glycerin suppositories I made use of suppositories containing ox gall; one or two grains of powdered ox gall was put in a hollow suppository. These were usually quite effective, but in some cases slightly irritating to the rectum.

The local measures described above are more especially adapted to cases of occasional constipation, such as result from a change of diet. Free indulgence in milk by those unaccustomed to its use is frequently followed by severe constipation. This condition may exist for several days without causing serious inconvenience, when suddenly relief becomes imperative. In a case like this it would be worse than folly to wait for the slow action of physic; immediate relief is demanded. Here copious injections of soap and water, or the use of glycerin suppositories, would be the most rational treatment.

Of all the remedies for the cure of constipation, aloes deserves the first rank. Most of the old writers, and some recent ones, tell us that aloes frequently causes hemorrhoids and aggravates them when already existing. This is a tradition that has come down from the fathers and is utterly without foundation. Given in the large doses that were formerly advised, it is no wonder that where hemorrhoids existed they should be made worse. Any powerful purgative is contraindicated in such cases.

Fordyce Barker says:* "It would seem therefore that the use of aloes for the cure of hemorrhoids in pregnant women would have been suggested by *a priori* reasoning, but I am not aware from anything I have read that it ever has been. I suppose that the general impression that aloes is contraindicated where there is any tendency to piles, and that it possesses emmenagogue properties, has had great influence in preventing this. In my own case the use of aloes for this purpose was the result of gradually accumulating observation rather than from any reasoning on the subject." I have prescribed aloes in small doses for patients suffering from piles time and again, and have never known of any unpleasant effects following its use. "The charge brought against aloes of producing piles is not borne out by my experience" (Fothergill). In truth, given in proper amount, it is by far the best remedy that we possess for constipation associated with hemorrhoids.† Furthermore, the habitual use of aloes does not sensibly affect its activity. It has been facetiously said, *Qui vult vivere anos noe, summat pilulas de aloa.* M. Audhoui‡ considers aloes the typical laxative. He further remarks that "aloes taken in sufficient dose with food excites the flow of mucus in the digestive tract, increases the secretion of the glands, provokes the contraction of the muscular tunic, and that with order, with moderation, without causing the least malaise."

This last attribute of aloes, whereby the bowels may be acted on thoroughly, gently, and with the nearest approach to a natural movement of any known drug, and without causing the slightest degree of nausea, is the one which commends it most strongly.

The dose of aloes is an important matter. The amount advised in the text books on materia medica, of 5 to 10 grains, is entirely too large.

Professor Wallace taught years ago that fractional doses of aloes would cure constipation where large doses would fail. He used to tell us to begin with 2 grain pills, and give one at bedtime for a week; then cut these pills in two, or substitute 1 grain pills, and continue with these for another week, and thus continue to subdivide until the patient was taking only $\frac{1}{2}$ or $\frac{1}{4}$ of a grain once or twice a day.

I followed this plan for several years with success, but since the appearance on the market of granules of aloin,§ the active principle of aloes, I have made use of them, on account of the smaller dose required. As in the case of aloes, the dose laid down in the standard works for aloin is also too large; 1 to 3 grains is more than is ever required for cases of the kind under consideration.

The granules referred to are made from $\frac{1}{15}$ to $\frac{1}{6}$ grain in size. The method of administration constitutes an important part of the treatment. I first order a blue pill, to be followed by a saline, which opens the bowels and makes a good beginning, after which I direct the patient to take two granules of aloin ($\frac{1}{15}$ grain) three times a day, after meals, for a week. If two are not sufficient, three or four may be taken at a time. The following week two granules are to be taken twice a day for a week. After a time—which varies in different cases—it will be found that two granules, taken once a day, preferably at bedtime, will be amply sufficient to secure a perfectly natural movement of the bowels. After finding by experience in individual cases the smallest amount that will cause the bowels to act, it is good practice to continue the medicine for several weeks or months for its curative effect. There are also several combinations, such as aloin, $\frac{1}{5}$ grain; belladonna, $\frac{1}{8}$ grain; strychnine, $\frac{1}{60}$ grain—this particular formula is very extensively used—which are alleged to be superior in their action to aloin alone or uncombined. This very popular and much vaunted formula is open to the following criticism: First, strychnine, in this amount, limited to a single dose, can have little, if any, effect on the peristaltic action of the bowels. The same is to be said of $\frac{1}{8}$ grain doses of belladonna. Further than this, these granules are not free from danger when taken *ad libitum*, as they practically are. Several cases of poisoning are on record from strychnine pills, or rather granules, and these are capable of causing the same mischief.

I have long since ceased to employ anything but the aloin itself, uncombined with anything else, for the following reasons: In the first place, after careful comparison, I fail to see that the addition of belladonna or strychnine to the aloin increases its purgative effect, the same amount of aloin alone giving equally good results. This I have demonstrated time and again, frequently on the same subject. Certainly there is no good reason for dosing a patient for a long time with powerful drugs like these, if the same results can be obtained without them.

Dyspepsia is sometimes associated with constipation, but not nearly so often as it is alleged to be. In those cases where indigestion is present, nux vomica can be used in the form of the tincture, giving a large or small dose, as the case seems to require. Other remedies appropriate to the case may also be added. In this way the constipation can be treated much more satisfactorily, both to patient and physician, than by attempting to combine all the remedies that may be indicated in one prescription.—*Therapeutic Gazette.*

* "Puerperal Diseases," p. 33.

† "The general belief that aloes tend to produce hemorrhoids is contraindicated by the results of experience; these bodies probably arise from the constipation which aloes is given to relieve" (Stille).—"National Dispensatory," p. 159.

‡ "Therapeutique Contemporaine," quoted in *Journal de Medecine et de Chirurgie*, Sept., 1881, p. 418.

§ Aloin may be prepared by W. A. Tilden's process, as follows: One part of aloes is dissolved in ten parts of boiling water, acidulated with hydrochloric acid, and allowed to cool. The liquid is then decanted from the resinous matter, evaporated to about two parts, and set aside for two weeks for crystals to form, the liquid portion is poured off, the crystals pressed and the adherent resinous matter separated by shaking with acetic ether, which dissolves the resin.—"U. S. Dispensatory," p. 160, 16th ed.

THE QUADRI-CENTENARY OF AMERICA'S DISCOVERY.

THE near approach of the time when we shall celebrate the lapse of four hundred years since the new world was first stepped upon by Columbus, prompts us to inquire when the four hundredth anniversary will exactly arrive. The determination of the answer is not the simple problem that it would at first appear to be. Some of the years during the period over which we are looking were leap years when they should not have been, if the calendar we now follow had always been in vogue; days were left out by different nationalities in different centuries, and years were begun in all seasons. According to the contemporaneous record, Columbus set sail on the 3d of August, landed on San Salvador on the 12th of October, and returned on the 15th of the following March.

Among the various Latin Christian nations of that period, the year was commenced at different times. In Pisa the year 1493 began the preceding March to the first voyage of Columbus, so from there his voyage appeared to be made in 1493; in Rome, most of the provinces of Italy, and probably in Spain, the year commenced at Christmas, so that these districts would regard his discovery as occurring in 1492; in Florence and England, the year commenced twelve months later than in Pisa, thus making the events attending America's discovery wholly in the year 1492; while in still other places, the years began on the 1st of January a year later, thus placing the landing of Columbus on San Salvador in 1491. We will use the calendar of England in connecting this event with the present time. To guard against the possible error of a day, the question as to when the extra day was added to February will need to be settled before we can be sure of the steps we are taking.

According to the time-honored custom, years divisible by four are leap years, in each of which February is lengthened by a day. The year 1492 was, therefore, a leap year according to the rule; but while in Pisa and Rome its month of February preceded the discovery by Columbus, in Florence and England it followed the discovery. If the former countries added the extra day before Columbus started on his voyage, and the latter after he had found the new world, it follows that they would not have had the same date for the day we are to commemorate. On searching the records for light on this question, we find among the foot notes of Macaulay's history the date 29th Feb., 1695, thus showing that the well known custom of adding the day in years divisible by four was not followed in England, but added in the preceding year, in correspondence with the other countries. Aside from the variation in the time for commencing the year, there have been two systems in vogue, differing from each other by three days in four centuries, and they have each been used during portions of the past four hundred years in all the countries we have mentioned. The first is the Julian system and contains in four centuries 300 common years of 365 days and 100 leap years of 366 days. The second is the Gregorian system, and contains in the same period 303 years with 365 days and 97 years with 366 days. Four hundred Julian years therefore contain 146,100 days, while the same number of Gregorian years contain 146,097 days. Neither is the number of days from the 12th of Oct., 1492, to 12th of Oct., 1892, evident on inspection, since the former mode of reckoning was used during a part of the time and the latter through the remaining period. In England, the change from the one system to the other was made in 1752 and eleven days were omitted from the calendar in that year. If the Julian system had been continued unbroken down to the present time, our present calendar would be found to be twelve days early, eleven days of this difference being accounted for by the exception just mentioned, and the other day on account of the year 1800 having been made a year of 365 days, when the Julian system would have given it 366 days. The actual number of days to the 12th of Oct., 1892, is therefore twelve days less than four hundred Julian years, or 143,088 days. In Russia the Julian system is still used, and these twelve days departure have not been made; therefore when they reach the 12th of Oct., 1892, four hundred Julian years will have passed since Columbus made his discovery, but when it is that date with them, it will be the 24th of Oct. with us.

The proper way to determine the date will be to base our calculations on the exact length of the year. Astronomers describe several kinds of cycles made by the earth, resulting in three kinds of years. The first cycle is the true revolution of the earth around the sun, bringing the stars again overhead at the same hour of night. This is the sidereal year, and has a length of 365 days, 6 hours, 9 minutes, 9 seconds. The second cycle is due to the slow revolution of the earth's orbit. The path of the earth around the sun is in an oval, which is not fixed in space, but revolves, as we might conceive a race track revolved on a gigantic turntable. The time required to return again to the same position in this oval path gives rise to the anomalistic year, and consists of 365 days, 6 hours, 13 minutes, and 48 seconds. The third cycle arises from the swinging around of the axis of the earth like the slow gyration of a top, so that the interval from a time when the north pole is turned farthest away from the sun till it is turned away again does not agree with the true year, but is 20 minutes less. Its length constitutes the tropical year and consists of 365 days, 5 hours, 48 minutes, $45\frac{1}{2}$ seconds. From these data we can readily tell how many days there are in four hundred of each kind of years. On making the calculations and collating them with the results already given, we will find that from the morning of the 12th of Oct., 1492 [old style], when Columbus landed on San Salvador, is:

146,088 days to the 12th of Oct., 1892;

Four hundred tropical years, or 146,096 days, 21 hours, to the early morning of the 21st Oct., 1892;

Four hundred Julian years, or 146,100 days, to the 24th Oct., 1892;

Four hundred sidereal years, or 146,102 days, 13 hours, to the evening of the 26th of Oct., 1892, in America, or to the morning of the 27th in Europe;

Four hundred anomalistic years, or 146,103 days, 20 hours, to the early morning of the 28th Oct., 1892.

The tropical year is the one that is most closely followed by our present received calendar, and if the reader will take the trouble to look up the day of the week according to it, as published in the Encyclopædia Britannica, art. Calendar, of the 21st of Oct., 1492, he will find the date to be Friday, which history tells us was the day of discovery.

This is the date that is expedient to follow, since it agrees with the calendar, and the years agree with the round of the seasons. However, since the sidereal is the true year, we may regard the calculations based on both as leading to correct anniversary dates. The former being the day when the sun will hold dominion in the sky the same number of hours that it did on that eventful day of discovery, and the latter bringing the same constellations in the sky that were witnesses to the first sighting of the new world.

S. W. BALCH.

128 Broadway, New York City.

[GARDEN AND FOREST.]

OUR CURRANTS.

THE currant crop should be one of our largest. The market is always good. The demand is never met by the supply. I never fail to obtain eight cents a pound, and this year have marketed all my crop at ten cents The fruit pays at five cents a pound. The bushes need strong, moist, but not wet soil. They should be kept clean and in a high state of culture, but they like partial shade. I grow them in the same rows with red raspberries, alternating the bushes.

The varieties best for the market are Versailles and Fay. There is little difference between these, and the preference is for Versailles. This currant is not easily obtained—that is, the genuine. It is magnificent in bush and bunch. Why Fay ever secured such applause as superior to all others is a wonder. It is hardly distinguishable from the Versailles. The cherry has a short bunch, some years very short. It is also a comparatively poor cropper, and is not well flavored. The sweetest currant is White Dutch; but when not very well grown it is over-seedy and small. White Grape is the first of all currants for the table. It is thin-skinned, not over-seedy, large, handsome, with superb bunches, a great cropper, and delicious in flavor.

The currant has the advantage of hanging on the bushes for several weeks, and is in order for the table for at least two months. One should have a few bushes of Prince Albert to lengthen out the season. Of course, if worms are allowed to defoliate the plants, the crop must be gathered very early and used for jelly, or it will sun-burn and sour.

The Crandall is not what it was sold for—a cross of native with foreign sorts. It is pure native, somewhat improved. But it is half a humbug, after all. The bush lops about, and must be tied to stakes. The size of the currant is only that of a large fruit of the ornamental Missouri currant grown in our shrubberies. The flavor is pleasant, but no improvement on that of the varieties grown for ornament. Let it be taken for what it is, and appreciated accordingly.

The propagation of the currant is very easy. Take cuttings a foot length; set these into the soil in a dry place in October or November. Pack down the dirt very tightly and leave them until spring. Then a part will be found to have rooted, while the rest will have calloused and are ready for planting if you desire. In setting such small plants pack the earth very tightly about them. It is the secret of success.

The only enemy the currant has generally is the well known worm that defoliates the plant. White hellebore dusted on will kill them. The best method of applying is to mix two tablespoonfuls of hellebore in

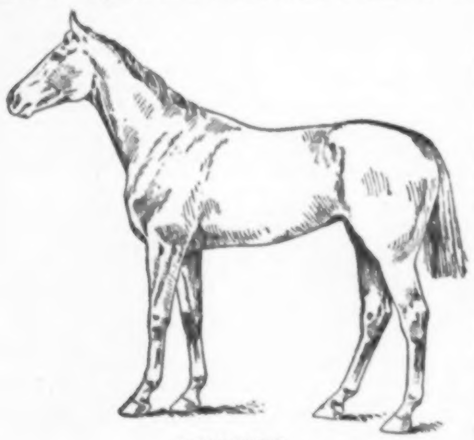
a pail of water with one teaspoonful of kerosene. Riley's emulsion of kerosene is easily made and kept on hand. It is the best way of using it. I apply exactly the same mixture to rose slugs. Two generations of worms appear each season, and both must be killed. One of them hatches as the fruit is setting; the other as it is ripening. The hellebore should be applied the last time without kerosene, as it is sticky and helps dust to adhere to the fruit. E. P. POWELL.

Clinton, N. Y.

ORMONDE AND SALVATOR.

ENGLISHMEN have a veneration for Ormonde, the great race horse that carried the Duke of Westminster's colors to victory in the most historic events of the English turf, and regard the son of Bend Or and Lily Agnes as the best horse that has appeared in any country in any age. Americans hold Mr. Haggin's champion, Salvator, in almost the same esteem, and a comparison would be interesting.

Ormonde was never beaten, but his American cousin cannot lay claim to that distinction, having suffered defeat on three occasions, twice as a two year old before he reached the full maturity of his powers, and once as a three year old while conceding weight to opponents of his own age. Turf history does not contain two brighter names than those of Ormonde and



ORMONDE.

Salvator, and although both left the turf as four year olds, they hold the proud position of being the largest winners in their respective countries, Ormonde's three years on the turf netting the Duke of Westminster $144,910, or £28,982, while Salvator earned a trifle over $20,000 less than that figure for the American banker, mine owner, and stock raiser who is so fortunate as to possess such equine treasures as Prince Charlie's best son and the game mare Firenze.

A study of the make-up of the English and American champions will cause even the most casual observer to pronounce Salvator as much the handsomer and more racer-like of the pair.

He is more the ideal of what turfmen designate a "model of racing lines." Yet runners, like trotters, go in all shapes, and the most ragged in appearance are not infrequently the speediest and toughest. A writer who saw Ormonde in 1886, when he was in the zenith of his powers, spoke thus in *The Sun* of the English champion:

"He is not a perfect beauty, nor is he a perfect horse to the eye. Probably no jury of horsemen on examining him would assign to him the foremost rank among his rivals of all ages, nor even among horses of his own years. His color is a dark bay, with the black rising to the houghs. But almost the first points that the observer notices is that there is a great deal of daylight under him. In other words, he might be called 'leggy.'"

Continuing, the same writer says:

"The feet are very good, and so are the pasterns. The cannon bones are far broader than is usually seen. The knees and houghs are exceptionally big and

SALVATOR.

clean, and as the eye rises further still and surveys the arms and second thighs, his power seems to grow and approach the ideal nearer and nearer. The shoulders are long, bold, and sloping, but I have seen finer. The neck does not emerge from them with the clearness often seen in other horses. The withers are moderate, and the body, beginning with its very deep girth, displays an admirably short back and long belly."

This critic found fault with Ormonde's plain head and neck, and thought forelegs were too close together, but the superb development from points of hip to hough excited his admiration. In walking or cantering Ormonde's action was not engaging, but it was poetry when galloping at a stiff pace or fully extended, the stride being long, low and sweeping.

Salvator has been called a leggy horse by good judges, but there is a preponderance of opinion by equally good judges to the contrary, and a close study of the excellent picture of the American king of the turf printed here will end in the reader reaching the conclusion that Salvator is a symmetrical horse. Few horses of his height have such general development, it being difficult to find out an absolutely weak point in his make-up. The shoulder is a trifle too straight for many, but it is well muscled and joins a strong back to quarters that are of unusual size and power.

The legs are magnificent, being broad, flat, and free from blemishes of any kind, while the feet are of the best. He is higher at the withers than Ormonde, and is deeper through the girth. Ormonde's quarter is squarer, Salvator's rump drooping perceptibly. The English pet is thicker at the throttle, and his head is coarser than that of the American crack. Salvator's action, whether cantering or at full speed, was perfection, and his temper is of the best. In color he is a light chestnut, with four white stockings and blaze in the face. Both Ormonde and Salvator should sire horses able to perpetuate their fame in hard-fought battles in time to come. Ormonde has been in the stud for two years, a portion of the time in the Argentine Republic, and Salvator will take a proud place in the Rancho del Paso stud in California next spring. Mr. John Mackay, manager of Mr. Haggin's breeding stud, left with his favorite a few days ago for California.

Mr. Mackay is very much in love with Salvator, and on his return from a trip through Europe last summer, during which he saw the most famous horses on the Continent, he asserted that none could compare with Prince Charlie's chestnut son. Salvator could undoubtedly win between $25,000 and $35,000 for Mr. Haggin next year if he were kept in training, but his owner declares that he shall send the horse to the stud sound in wind and limb, believing that his progeny will be stronger and speedier for the precaution. His sire (Prince Charlie) was a roarer, and his English prototype, Ormonde, became one in the beginning of his four year old career, and had to be retired eventually because of that fact. There was considerable prejudice against breeding to Prince Charlie on that account, but not one of his get is thick-winded, with the possible exception of Prince Fonso.

There is no way of determining the relative speed of the two horses in question, but those who have seen both think that Ormonde could beat Salvator when both were at their best.—*N. Y. Sun.*

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